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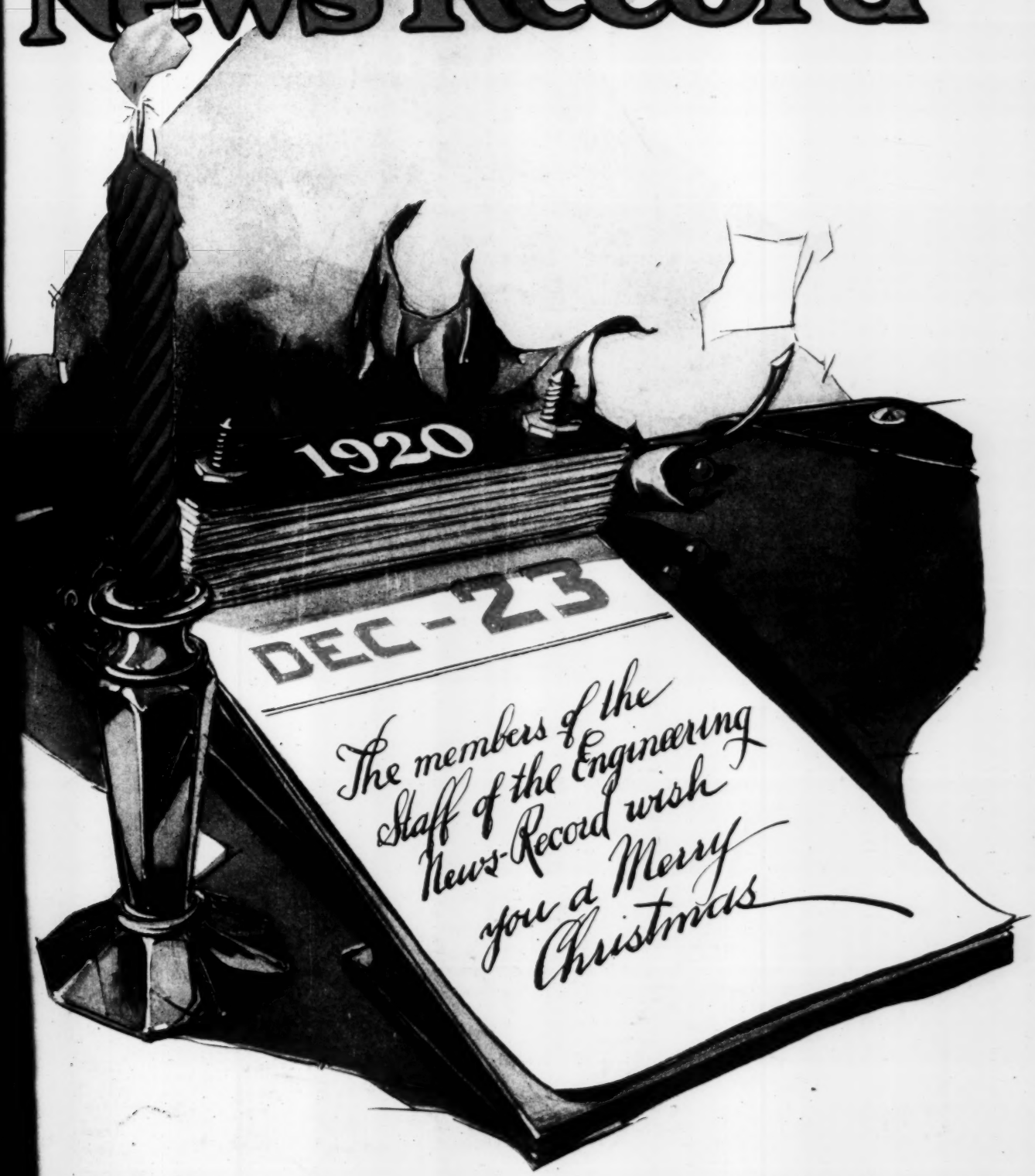

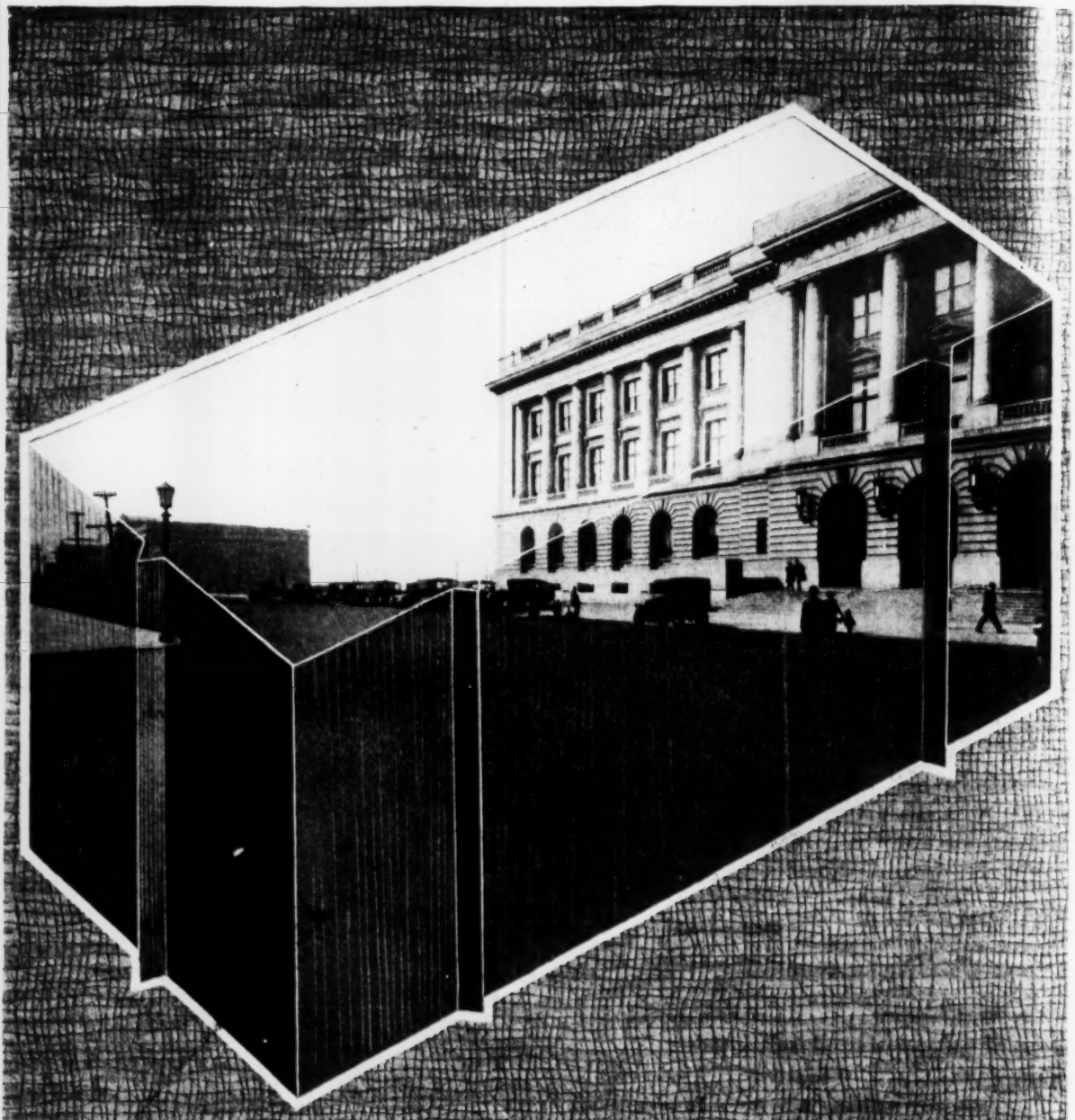

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING
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Port Discussion

LAST WEEK there was presented before the New York Section of the American Society of Civil Engineers a technical discussion on New York's port problem, remarkable for its high quality and its broad treatments. Since the report of the New York-New Jersey Port and Harbor Development Commission has not yet been made, Mr. Cresson presented only an analysis of the many phases requiring solution, but the discussion that followed brought out striking recommendations for an ultimate solution. A report of the meeting appears elsewhere in this issue and merits a thoughtful reading by port-terminal engineers everywhere.

New Light on Water Hammer

NEW light is thrown on the vexed subject of water hammer by Prof. Durand's valuable discussion on p. 1212. The last part of the paper, relating to water hammer under conditions of partial or incomplete reflection at the valve, is believed to be quite new, valuable, and likely to dispel some of the doubts and uncertainties which hydraulic engineers have had regarding the applicability of the best previous existing formulas. Experimental data on the degree of reflection at the valve are needed before it can be determined what, if any, economy in the design of penstocks and surge tanks can be effected by consideration of actual rather than ideal conditions of complete reflection of the pressure wave.

Foreign Financing

MUCH deserved commendation has been accorded the launching at Chicago week before last of the Foreign Trade Financing Corporation, which will have a loaning power of $1,100,000,000. Our foreign-trade relations are in a bad condition. The organization of this banking instiution will help more than any other action that has been taken to enable European powers suffering under an adverse rate of exchange to buy our products. Great as the step is, however, it is not a cure-all and we must expect neither full relief for European countries nor immediate, or even rapid, equalization of the exchanges. European governments alone owe our government $10,000,000,000, while the financing ability of the new organization is approximately one-tenth of that sum. Nevertheless, the importance of the step intrinsically and as an example should be recognized.

Salem Typhoid Outbreak

WATER-BORNE typhoid epidemics that prostrate ten per cent of the population of a city are happily becoming rare. Meanwhile prompt and effective methods for combating the spread of the disease and for ameliorating the appalling conditions in typhoid stricken communities have been elaborated. These facts lend unusual interest to the epidemic at Salem, Ohio, officially reviewed in concise detail on p. 1244. The Salem epidemic, like the one at Schenectady early this year (see *Engineering News-Record*, Dec. 2, p. 1101), shows that a water supply itself pure, even though from an underground source, must be guarded against pollution en route to the consumer. An abandoned river intake at Schenectady, flooded at high water, led to the pollution of the water supply, much gastroenteritis and 53 cases of typhoid. At Salem, the menace was continuous and when the epidemic came it was of large proportion compared with the Schenectady outbreak. These and other typhoid outbursts of the last few years, even though most of them have been minor, show that eternal vigilance is still essential for the maintenance of pure water supplies and for a continuance of the remarkable progress that has been made in the elimination of water-borne typhoid.

Highway Contracts

HIGHWAY contract provisions have been under discussion by a joint committee appointed a year ago by the Association of State Highway Officials and the Associated General Contractors. There are, it is generally recognized, many unsatisfactory features in the contractual relations on highway work. Nevertheless, there is common ground and it was with the hope that this ground would be broadened that the committee was appointed. Unfortunately, after a year of labor the committee was not able to make a report at Washington last week. It was distinctly stated that the committee could not agree. No information as to the character of disagreement has been given out so that one can express only general regret that the deliberations have been abortive. We believe that both of the parent organizations, through their executive bodies, should counsel with their representatives on the joint committee to the end that the cause of disagreement may be removed. Even a frank statement of the subject on which there is a disagreement would be helpful, for the subsequent discussion by the members of the two bodies at large would help to clarify and settle the issues. The matter is too important for the interests of the public to allow it to drag.

Concrete Road Reinforcement

WHETHER reinforcement is of advantage is one of the controversial points in concrete-pavement design. Many believe in its efficacy in preventing cracks or at least in delaying the breaking up of the slab if cracks occur. In fact, some state highway departments call for reinforcement in all their concrete roads. Others, on the other hand, are emphatic that reinforcement is not worth what it costs. Some time ago H. Eltinge Breed undertook a study of matured roads to learn the

effect of reinforcement, later widening and completing the examination on behalf of the National Steel Fabric Co. His conclusions can be found in an article on page 1231 of this issue. His observations show that reinforcement prevents cracking, that it is worth what it costs. We have no doubt, however, because of the depth of feeling on this subject, that there will be disagreement with Mr. Breed's findings. It is, nevertheless, a definite contribution to the literature of the subject and should be amplified by the experiences of other highway engineers. Not less interesting than these conclusions of Mr. Breed are the adoption in his own practice of 40 lb. of reinforcement per 100 sq.ft. instead of the customary 25, and also his use of two layers of reinforcing steel. The latter design carries 75 lb. per 100 sq.ft., 40 in the lower and 35 in the upper layer. Mr. Breed's article thus suggests two lines for discussion and further data—regarding simple reinforcement and regarding the advisability of the two-layer design. While it may not yet be general, the opinion has been frequently enough expressed that the time for true *reinforcement* of concrete pavements has come, to suggest that there is a definite drift toward use not merely of some steel but of much more steel than has heretofore been used.

Government Economy

THE opening of a session of Congress is always preceded in an editorial office by the receipt of letters urging that certain proposed legislation be given publicity in the columns of the journal and, if possible, editorial approval. This year there has been an exception to that rule in so far as there have been no communications from engineers or contractors urging projects or measures pertaining to engineering and the construction industries. That fact is, we believe, significant. The feeling among thoughtful men is that there must be the utmost economy in Government expenditures. The situation is further emphasized by the fact that the appeals for editorial support on congressional measures have been made only for the adoption of the budget system and the modification of the tax laws. How far the cutting in Washington should proceed cannot be expressed as a generalization. Each governmental service needs separate investigation and appraisal. Those that immediately prevent heavy loss to the community, such as the measures for keeping down crop pests and for the extirpation of disease, must be maintained at full vigor. However, we must expect heavy curtailment in research, even though one can reasonably demonstrate that it would be a good investment of Government funds. Even the shrewdest business corporation often finds that instead of making a profitable investment it must conserve its cash and husband its resources. A similar situation faces the Government today. Engineers and contractors must, therefore, expect neglect of favorite agencies and projects, existing and prospective, unless they themselves, like the proposed department of public works, are measures of economy. The Government must reduce its expenditures.

Progressive Highway Thinking

WAYNE COUNTY, Mich., has long had the reputation—and justly so—for progressive highway work. Its road system was for years the Mecca of those who wished to study concrete highway construction. Therefore, it is not a surprise to learn that the Wayne County road commissioners continue to think in a forward-looking way regarding their problems. Surfacing—as to design, construction and maintenance—they consider quite well settled for present and reasonable future conditions. Their concern is rather with the effort to foresee future needs. They believe that highway traffic is certain to increase in weight and have, therefore, adopted a 24-ton load as the standard in bridge design. They have advocated the gradual acquisition of forested areas in different parts of the county, so that there may be in the not distant future a goodly-sized forest-preserve system, tempting the city people into the country. Finally, they believe that on certain of their roads the provision of lighting and of sidewalks require consideration. Lighting would encourage the shifting of part of the heavy day traffic to the night, and enable the traffic to proceed at greater speed and in greater safety. Sidewalks are needed that pedestrians may be safeguarded along the heavily-traveled roads. The consideration of these problems indicates that the Wayne County commissioners, under the able leadership of Edward N. Hines, are keenly alive to their responsibility and have profited by the lessons of the past rapid expansion of traffic on their improved highway system.

A Note of Inconsistency (?)

IN COMMENDING in the previous note advanced thinking in highway practice we may be charged with inconsistency, for we have urged in these columns a strict examination of the propriety of expenditures under present financial conditions. The charge, however, in our judgment can not be sustained. The thinking in question does not necessarily mean immediate expansion of expenditures. It does mean, though, that when conditions are easier those who have visioned their responsibilities broadly will be ready to take steps in directions called for by reasonable traffic demands. Those who restrict their thinking only to present needs are not apt to be able to handle large problems effectively when the demand comes suddenly upon them.

Terminal Motor Trucking

A FAIR and full trial of the motor truck in terminal service was urged in these columns last week with reference to the problems of inland cities. This suggestion was based on two years of highly successful operation in Cincinnnati, where demountable truck bodies are employed for less-than-carload interchange between railroad main and substations. It is important to note, however, that the method, necessarily in modified form, is applicable as well to the country's most difficult terminal problem—that of the port and city of New York. B. F. Fitch of the Cincinnati Motor Terminals Company has publicly proposed such a plan in detail for New York, and such authorities and students of the port problem as J. J. Mantell, of the Erie Railroad, William Barclay Parsons, F. L. Molitor and E. P. Goodrich, under one form or another, have pointed to store-door delivery as an essential of a satisfactory solution. Even under Gustav Lindenthal's Hudson River Bridge plan, detailed in this issue, the motor truck would play an important part in handling l.c.l. freight. Mr. Fitch's proposal, however, does not call for big capital outlay, but the use of sulplus capacity of present passenger-vehicular ferries to carry truck loads between

New Jersey rail transfers, zone-station warehouse distributing points and store-doors in Manhattan. While the *Engineering News-Record* believes that the bridge must ultimately come, for rapid transit as well as for freight and vehicles, it is distant, while the truck plan could be rapidly effected, providing for the fullest use of present plant at comparatively small cost. Moreover, such a method of intensive motor-truck operation, effectively tied in with existing terminals, gives promise of fulfilling four of the five major requirements laid down as fundamental to satisfactory freight distribution at the port of New York by engineers who have given the subject careful thought. These requirements are: Division and distribution rather than concentration and congestion; a belt railroad system; prodigious expansion of storage; a single organization to direct and conduct distribution, both in- and out-bound, and, finally, store-door delivery. Any large plan for efficient terminal-operation at the port of New York will no doubt be opposed by some intrenched interests selfishly fostering wasteful methods so widely condemned by engineers. However, those charged with the solution of the port problem should give full consideration to a test of a system successfully established elsewhere, particularly since it is fully agreed that other proposed solutions will require very heavy capital expenditures for equivalent results.

City Traffic Distribution

PASSENGER transit facilities in cities commonly operate to produce or intensify concentration. Their real function, however, is distributive, and in recognizing and utilizing this function the municipal engineer has the opportunity to do important constructive service to his community.

In large cities the necessity of striving to distribute traffic and population is rather obvious, and transit improvements usually are planned to this end. In the small city it is less easy to perceive the importance of encouraging distribution by the layout or control of transit lines, and here, perhaps, the principal errors are committed. Important lessons in this field may be learned by the small city from the large.

Motor traffic has helped to emphasize urban concentration suddenly and sharply. It has led many towns and cities of moderate or even small size to realize for the first time that they suffer from excessive concentration. But motor traffic is only an index of concentration, not a cause; rather the reverse. Anti-parking ordinances, therefore, while they have decreased motor congestion, have not remedied the general condition of low efficiency of business and slowed-down community activity through the retardation of passenger and freight movement that concentration produces.

Street-car and other transit facilities with fixed routes differ from the automobile in deliberately seeking the most concentrated sections and streets. They aim to get the traffic, and find best returns when they take fullest advantage of concentration of people. By doing so they inevitably increase downtown concentration. This tendency can be prevented or limited, however, by suitable control in laying out transit lines, and to some extent in subsequent rerouting.

In the small town these conditions are not at once apparent; in very large cities they stand out unmistakably. Downtown Chicago pictures clearly the confining effect of railway, street-car, and elevated-railway concentration superadded to the effect of unfavorable geography. By contrast, Philadelphia, for example, exhibits the benefits of distributed transit layout in decentralizing population and traffic. In New York the construction of the first subway favored an intense concentration—though this merely adapted itself to pre-existing tendencies of growth—whereas the recently built subway lines are beginning to develop a strong distributing effect. Such actions and tendencies, we believe, are worth close study on the part of the engineers responsible for the development of small communities; for city development is most easily guided when the city is small.

Large cities present other situations which exhibit the relations of traffic and concentration more in detail, and these supply particularly valuable material for study. In this light there is special interest in an attempt recently made in New York to bring about the construction of a local subway loop to encircle a part of the up-town business district, a district already highly overconcentrated and provided with transit service fully as good as that of other parts of the city. The proposed loop—which by the way has been rejected—would very surely have created an iron-bound district like that within the Chicago Union Loop, with most unfortunate results on the freedom of traffic movement, and clearly to the injury of the city at large. The movement was promoted by commercial and realty interests within the proposed loop area, but it was opposed by the technical authorities of the city, who appreciated the harmful effect of such transit localization on municipal conditions.

In smaller cities, traffic localization proposals of remotely similar character are sometimes made, and because their effects are less pronounced than in a large city they usually are judged to be advantageous and find acceptance. Reference to the situation in a large city, as in the instance cited, is capable of giving decisive help in such circumstances by illustrating the real effect of the proposed localization and making possible a correct balancing under the given conditions of harmful against beneficial effects.

Without restriction to special cases of this kind, however, we would emphasize the need in all cities, small as well as large, of developing the distributive function of city transit facilities by properly controlled lay-out and operation. The most fertile field for effective work in this direction is the small city, where the close interrelation of transit and concentration is most likely to be overlooked. It should be one of the objectives of the municipal engineer to combat the many tendencies toward concentrating traffic routes in a few downtown streets.

He will have to meet hostile arguments of many kinds, but the facts, if rightly interpreted, should easily overcome them. The most cogent plea, that transit lines should be put where the traffic is centralized, can be met on the basis of a proper analysis of street and traffic conditions and it it cannot be so met it should prevail. Least logical, though perhaps most tenacious, is the opposition offered not by transit operators but by selfish property interests and by civic-pride enthusiasts of the type which finds its satisfaction in the sight of a street choked with crowds. In overcoming all such opposition, however, the engineer will be doing true public service.

Water Hammer in Pipe Lines*

Studies Extended to Include Effects of Imperfect Reflection at Discharge End, Friction, Non-Uniform Change of Valve Opening and Imperfect Action of Discharge Opening as a Nozzle

By W. F. Durand
Professor of Mechanical Engineering, Stanford University, Cal.

THE primary purpose of the present paper on water hammer in pipe lines and especially of that part relating to partial reflection has been to extend the general method hitherto employed in treating this problem to include the case of assumed partial reflection and thus to provide a method of analytical treatment which may serve as a basis for the analysis of experimental observations taken with a view of throwing some light on this general problem. With such observations in hand the methods and results developed in the present paper should serve to direct such analysis intelligently and thus aid in a determination of the degree of accoustic reflection to be expected at a partially open valve discharging a liquid.

Shock or water ram in pipe lines has been developed in some detail by Joukovsky and later by Allievi and others. *Memoirs* Imperial Academy of Science, St. Petersburg, 1897, Vol. IX; *Annali* della Società degli Ingegnieri, Rome, Vol. XVII, 1902. The basic principles or assumptions involved in the treatment include the following:

(1) The analysis of the continuous valve movement in opening or in closing into a series of differential elements after the usual manner of differential analysis.

(2) Recognition of the elementary pressure change (increase or decrease) consequent upon the elementary valve movement with its resultant change in discharge area.

(3) Consideration of the liquid within the pipe together with the pipe itself as constituting an elastic system capable of receiving and transmitting longitudinal waves, compression or expansion, with accompanying change of pressure, increase or decrease.

(4) The assumption that each elementary change of pressure at the valve (increase or decrease) will give rise to a corresponding wave (compression or expansion) which will then be propagated the length of the pipe with a velocity dependent upon the characteristics of the system comprising liquid and pipe conjointly.

(5) The assumption that such elementary pressure waves, will, at the upper or reservoir end of the line, undergo complete or perfect unloading, which unloading will then be propagated or reflected back to the valve end of the line. This assumption is based on the consideration that the upper end of the line is a point of uniform pressure and therefore while admitting movement will not permit pressure change. It is therefore like the free end of a spiral spring undergoing longitudinal vibration, or again like the mouth end of a closed organ pipe.

A complete picture of the phenomena, as assumed, may be readily obtained by considering a straight coiled elastic spring moving longitudinally and suddenly at the forward end coming into contact with a fixed wall. A wave of compression will travel along the spring until it reaches the free end, at which instant the entire spring is in a state of compression at rest, and with its former energy of motion stored for the moment as potential energy in the compression of the spring. Following this the compression will begin to unload at the free end by a reverse movement of the particles of the spring, and such unloading will be propagated back to the fixed end of the spring as a wave of relative expansion (back to normal). At the instant of complete unloading the entire spring is in motion in direction the reverse of its original motion and in amount equal (assuming perfect elasticity). The energy is therefore now again all kinetic with motion reversed.

(6) The next assumption made is that the valve end of the pipe constitutes a fixed end of the vibrating column similar in effect to the closed end of a closed organ pipe or to the fixed end of an elastic spring, and at which point motion is suppressed while pressure changes may develop.

It thus results that the kinetic energy, reversed in direction, and which reaches its full amount just as the unloading reaches the valve end of the line, will tend to carry the pipe contents bodily away from the valve end. This will result in a reduction of pressure at the valve and thus there will be started a wave of reduced pressure or of expansion, traveling from the valve to the free end, following which will be a reversal or return to normal pressure with forward movement starting at the free end and propagating back to the valve end. In particular it is assumed that this reflection at the valve end of the line is complete.

The phenomena outlined in (5) and (6) are entirely similar to those manifested in a column of air vibrating in a closed organ pipe, the closed end of such pipe corresponding to the valve end of the pipe line, or again to those in a spiral spring, fixed at one end and free at the other, and undergoing longitudinal vibration.

Following these basic assumptions the application of familiar principles of mechanics gives for the velocity of the longitudinal wave along an elastic liquid within an elastic pipe the following value:

$$S = \sqrt{g\frac{J}{w}} \qquad (1)$$

when S = velocity in feet per second
g = gravity acceleration = 32.16
w = density of water, pounds per cubic foot
J = virtual cubical co-efficient of elasticity of elastic liquid within the elastic pipe

J is then given by the relation:

$$\frac{1}{J} = \frac{1}{K} + \frac{1{,}944\,r}{t\,E} \qquad (2)$$

Where K = cubic coefficient of elasticity of liquid = for water, 43,200,000 with foot as unit.
E = linear coefficient of elasticity of pipe material = for steel, 4,032,000,000 with foot as unit.
r = radius of pipe (inches)
t = thickness of pipe wall (inches)

The numerical value 1,944 also includes an assumed value of 3.6 for Poisson's modulus for steel.

Again let $\alpha = S/g$
ds = elementary change in velocity of flow.
dh = elementary change in pressure head accompanying velocity change ds.

Then likewise from well-known principles of mechanics we derive:

$$dh = \alpha ds \qquad (3)$$

We have thus far given in brief resumé the basic principles used by Joukovsky, Allievi and others in the usual treatment of the subject, together with the resultant basic relationship between an elementary change in the velocity of flow and the resultant or accompanying pressure change; see (3) above.

Restrictive Conditions (see treatment by Allievi).—In the application of these principles to actual problems of pipe-line flow it has been customary to assume for simplicity various restrictive conditions rendering the treatment of the problem simpler but omitting thereby the influence of certain important factors which cannot but have an important bearing on actual numerical results. These conditions are as follows:

(1) The assumption of complete or perfect reflection at the valve end, regardless of the fact that the valve may during the period of reflection be partly open with water issuing therefrom.

(2) The omission of the effect due to friction or otherwise the assumption of a frictionless liquid in so far as friction may effect the values of the pressure head h.

(3) The omission of the head due to the velocity $v^2/2g$.

*A paper read before the National Academy of Sciences, Washington, D. C., April, 1920, heretofore printed only in a brief academy abstract.

(4) The assumption of a uniform time rate of valve area change (increase or decrease) in opening or closure.

(5) The assumption of perfect efficiency of the valve considered as a nozzle, or otherwise, the neglect of any loss of energy in the passage of the water through the valve.

The results due to (1) are uncertain in amount simply because we lack experimental research on the influence of the factor. It is obvious, however, that reflection at the valve end must often be far from perfect, especially in cases where the area of full opening approaches the cross-section area of the pipe and when the valve is nearly wide open.

The results due to (2) will depend much upon the hydraulic characteristics of the case. Where friction absorbs a large part of the actual head its omission may involve serious error; where friction absorbs but a small part of the actual head the importance of its omission is correspondingly reduced.

The results of condition (3) are usually not important since, as a rule, the head due to the velocity is but a small part of the total head.

The results of condition (4) will depend on the character of the valve movement and the extent of its departure from the condition assumed. In the usual case the rate of area change is not uniform, especially at the beginning of the movement. In many cases, however, the rate of area change may be approximately uniform over a considerable part of its course.

The results of condition (5) will depend on the type and form of the valve. They will be small in the case of a needle nozzle, but relatively more significant with most other types and forms of valve.

Any extended discussion of the influence due to these various restrictive conditions is beside the purpose of the present paper. It will, however, be clear that as a result of the effects due especially to conditions (1) (2) and (4) any ideal solution based thereon may represent something widely removed from the results in the actual case.

It will therefore be of interest to essay the analytical treatment of the problem, using the same basic physical principles as previously outlined but including within the treatment recognition of the five conditions as they exist in actual practice—imperfect reflection at the valve, friction in the pipe line, velocity head $v^2/2g$, any time rate of valve area change, and loss of energy through the discharge valve.

It will be found convenient to undertake this program in two stages, first including all conditions except (1) and then extending the treatment to include imperfect reflection.

Treatment of Problem With Removal of Restrictive Conditions (2), (3), (4), (5).—To fix the ideas we shall first assume the case to be one of valve closure. It will then be found that with appropriate interpretation this treatment includes that for valve opening likewise.

Let L = length of line

$z = 2L/S$ = time for round trip of accoustic wave from valve back to valve.

h = excess pressure head (summation of elements dh)

T = time for complete valve movement.

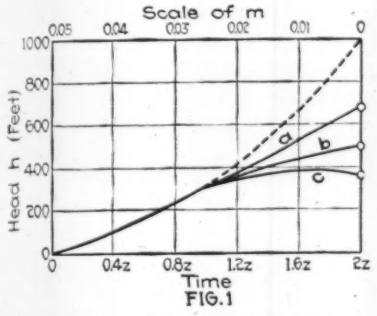

FIG. 1

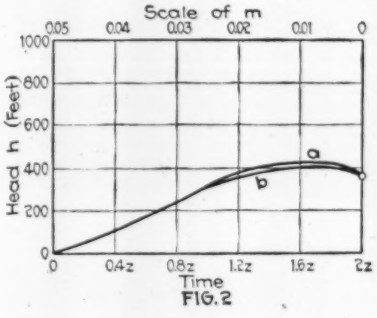

FIG. 2

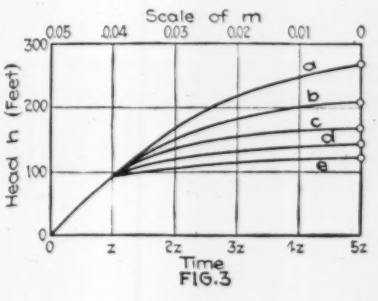

FIG. 3

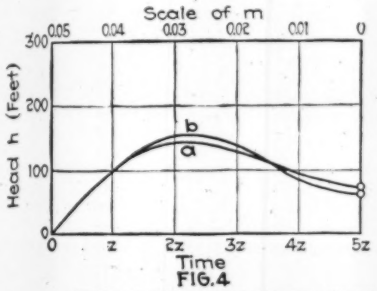

FIG. 4

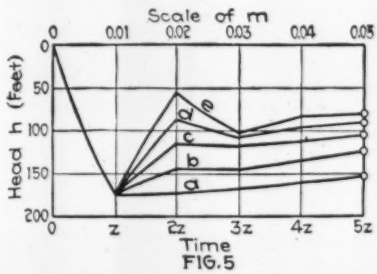

FIG. 5

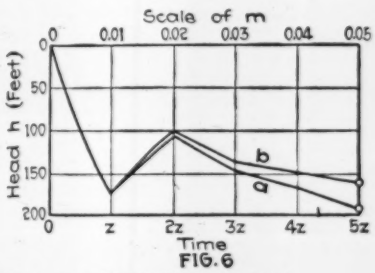

FIG. 6

FIGS. 1 TO 6. HISTORIES OF PRESSURE HEADS, H, WITH ASSUMED PARTIAL REFLECTION AT VALVE

Valve closure in first four figures; opening in last two. Values in all figures as follow: L = 4,000; H = 500; m for full opening = 0.05; m for complete closure = 0.00; Z = 2; T = 2z.

Percentages of reflection at valve:

Fig. 1 (Closure): Case a, .00; b, .60; c, 1. The dotted line shows the course of the curve with full reflection for full closure in time z.

Fig. 2 (Closure): Case a, $(m_0 - m)/m_0$; b, s/V_0.

Fig. 3 (Closure): Case a, .00; b, .25; c, .50; d, .75; e, 1.

Fig. 4 (Closure): Case a, $(m_0 - m)/m_0$; b, s/V_0.

Fig. 5 (Opening): Case a, .00; b, .25; c, 50; d, .75; e, 1.

Fig. 6 (Opening): Case a, $(m_1 - m)/m_1$; b, $(v_1 - v)/v_1$.

Other notation as before.

In a problem of this character any equation giving the value of pressure, pressure head, velocity, etc., will refer to some instant of time t and to some point in the pipe line. For the present we shall assume the latter as the valve or discharge end.

As a notation of special convenience in this problem quantities with no subscript will refer to time t, quantities with subscript 1 to time $(t - z)$, quantities with subscript 2 to time $(t - 2z)$, etc.

Then assuming complete reflection at the valve the application of the basic equation (3) to the physical conditions assumed gives immediately the equation

$$dh = \alpha\,[ds - 2ds_1 + 2ds_2 - 2ds_3 + \text{etc}] \ldots\ldots (4)$$

This gives a measure of the element of pressure head dh developed from time t to $(t + dt)$ as the sum of a series of terms. The first of these, αds, represents the element generated at the valve itself by a small movement which results in an elementary velocity change ds. The second term, $-2\alpha ds_1$ represents the element generated at the valve at the time $(t - z)$ and which has, in the meantime, traveled to the free end and back again to the valve, arriving just at the time t and by complete reflection now gives a negative element of pressure head, $-2\alpha ds$. The third term, $+2\alpha ds_2$, represents the element generated at

the valve at the time $(t - 2z)$ and which has, in the meantime, completed one full cycle of four traverses of length L and now reaches the valve at time t and by complete reflection gives a positive element of pressure head $2\alpha ds_2$, and similarly for successive elements.

All of this is, of course, simply an expression of Joukovsky's theory in somewhat simpler form as regards notation.

From (3) we have by integration for any given period of time:

$$h = \alpha\ (s - 2s_1 + 2s_2 - 2s_3 + \text{etc}) \quad (5)$$

It is readily seen that the number of terms will be given by the whole number next below t/z, and that they will have alternately plus and minus signs according as they represent elements which have made an odd or even number of double traverses of the length L.

Equation (5), thus representing the integrated result at the valve for a time period 0 to t, comprises successive terms each of which represents the summation of a series of elements αds (as in equation (4), all of which are similar as to sense and time history (number of double traverses of pipe-line length). Thus, for the first term the time period is 0 to t, giving the summed effect (all in the positive sense) of all elements as formed and previous to propagation or reflection. For the second term the time interval is 0 to $(t\text{-}z)$, giving the summed effect (all in the negative sense) of all elements which have had time to make the double traverse $2L$ with return to the valve and reflection at that point, and similarly for the successive terms.

Rewriting (5) we have $h = \alpha\ (s - 2s_1 + 2s_2 - 2s_3 + \text{etc.})$ ..... (5)

We shall have similarly $h_1 = \alpha\ (s_1 - 2s_2 + 2s_3 - \text{etc.})$ ..... (6)

These two expressions, after the terms in s, have the same terms with opposite signs.

Hence: $h + h_1 = \alpha\ (s - s_1)$ ..... (7)

Again in (5) put $B = 2s_1 - 2s_2 + 2s_3 - \text{etc.}$

We have then $h = \alpha\ (s - B)$ ..... (8)

Noting also the make-up of h as in (6) we have $h_1 = \alpha\ (B - s_1)$ or $\alpha B = h_1 + \alpha s_1$ ..... (9)

Thus from either (7) or (8), (9) it appears that the value of h for a given time t can be immediately determined if we can find s for the same time and also knowing h and s for the time $(t - z)$. These results are of remarkable simplicity, connecting, as they do, successive values of h separated by the time interval z.

The determination of the values of h during any period of time in general involves three distinct phases or time periods: (1) t between o and z; (2) t between z and T; (3) t beyond T.

With proper interpretation (7) (8) and (9) apply generally to all three periods. Thus for the first period the subscript 1 implies a time $(t - z)$ negative, and in such case the term is to be omitted, giving in (7)

$$h = \alpha s \quad \ldots (10)$$

For the second period the equations apply as written.

For the third period, for $t = T$ and beyond, s becomes v_o. Hence for values of t between T and $T + z$ we shall have from (7)

$$h + h_1 = \alpha\ (v_o - s_1) \quad \ldots (11)$$

while for $(t - z) > T$ or $t > (T + z)$, both s and s_1 become v_o and we have

$$h = -h_1 \quad \ldots (12)$$

It now remains to provide means for the determination of the value of s corresponding to any given time t.

Let

A = cross-section area of pipe
a = efflux or outflow area through valve
$m = a/A$
u = velocity through valve
v_o = initial velocity of flow
v = velocity of flow in general
s = aggregate velocity change $= v_o - v$
f = coefficient of efflux through valve
H = head
C = Chezy coefficient
r = hydraulic mean radius

We may then write three equations as follows:

$$v = mu \quad \ldots (13)$$

This expresses the continuity of flow along the pipe and through the valve.

$$h = \alpha\ (s - B = \alpha\ (v_o - v - B) \quad \ldots (14)$$

This gives from (8) the excess head developed at the valve corresponding to any reduction of velocity $s = (v_o - v)$, and hence the excess head at the valve at the instant when the pipe velocity is v.

$$\frac{u^2}{2g} = f\left(H + h - \frac{Lv^2}{C^2 r}\right) \quad (15)$$

This expresses the head on the discharge side of the valve, $u^2/2g$, transformed under efficiency f from the net head just back of the valve, and made up of the original head H plus the excess head h, minus the friction head $L\ v^2/C^2\ r$ as given by the familiar Chezy formula.

Putting (15) all in terms of u and transforming we have

$$Mu^2 = H + h \quad \ldots (16)$$

Where $$M = \frac{1}{2gf} + \frac{Lm^2}{C^2 r}$$

If then between (13), (14) and (16) we eliminate u and v and reduce the equation in h, we shall find

$$h^2 - 2\ (E + F)\ h + E^2 - 2FH = 0 \quad \ldots (17)$$

where $E = \alpha(v_o - B)$, $F = \frac{(\alpha m)^2}{2M}$ and $\alpha B = h_1 + \alpha s_1$

Solving for h we have

$$h = (E + F) - \sqrt{F^2 + 2F\ (H + E)} \quad \ldots (18)$$

When $m = 0$, $F = 0$ and $h = E = \alpha/(v_o - B)$ as in (8) with $s = v_o$.

For the period of time 0 to $t = z$, we shall have $B = 0$ and the above equations will simplify accordingly.

Having found h from (18), u follows from (16), v from (13) and then $s = v_o - v$. We then find αs, add h and thus find the value of B and of E for the instant of time z ahead.

It is to be especially noted in the equations thus developed that: (1) The influence of friction is represented by the term Lv^2/C^2r in (15) or in the values of M and F in the final solution of (18).

(2) The velocity head is implicitly included in equation (15) since H is the total initial head and H — friction head + excess head h will equal total head at valve, composed partly of pressure head and partly of velocity head.

(3) The solution is entirely unrestricted so far as the time rate of valve movement or rate of change of a and m are concerned. The various equations expressing h as the sum of a series of terms are entirely independent of any term expressing the time rate of valve movement. The valve opening is represented solely by the factor m which appears in equation (13) and in F, and no matter what the character of the valve movement may be, so long as it is known, it will be possible to assign to a series of values of t the corresponding series of values of m. This insures, therefore, the solution of the problem for any assigned rate or character of valve movement.

(4) The influence of nozzle inefficiency or loss of energy in flowing through the valve outlet is represented by the factor f in the terms M and F.

Pressure at Any Point in the Line.—The discussion thus far has related solely to the pressure at the valve. The same principles generalized for any point P at a distance x from the valve enable us to write down a general equation similar to (5) in the form

$$h = \alpha(s_{t-i} - s_{t-(z-i)} - s_{t-(z+i)} + s_{t-(2z-i)} + s_{t-(2z+i)} - \text{etc.} \quad (19)$$

In this and subsequent equations i = time x/S.

As in (5) each of these terms represents the summation of those parts of the final result which have had, so to speak, a common life and which thus admit of summation. The first term is the summation of the elements generated at the valve and which have at least traversed the distance x between the valve and the point P, distant from the valve by the time interval i. The second term is the summation of the elements generated at the valve

and which have at least traversed the distance L to the upper end and back again to the point P, a distance $(2L - x)$ and requiring a time $(z - i)$. These come back as an unloading of pressure and hence appear with the negative sign. The third term is similarly the summation of the elements which have at least traversed the distance L to the upper end and back again to the valve and back by reflection there to the point P, a distance $(2L + x)$ and requiring a time $(z + i)$. This likewise operates as an unloading term and hence appears with the negative sign. Similarly the other terms represent the summation of elements corresponding each to a common distance of propagation and approaching P alternately from the upper end and from the valve.

It is of interest to note that when the point P is at the valve and $x = o$, the two unloadings represented by the second and third terms occur simultaneously at the valve and become by their sum $2s_{t-z}$ or $2s_i$, as in equation (5). In this manner by the assumption of $x = o$, or $i = o$, equation (19) becomes reduced to (5) and the latter is thus seen to be only a special case of the former when $x = o$.

Writing equation (19) for time $(t - z)$ and adding the two values thus found, we have by the cancellation of all terms after the second,

$$h + h_1 = \alpha(s_{t-} - s_{t-(z-i)}) \qquad (20)$$

It will be noted that at any given instant of time, s is the same throughout the length of the pipe. Hence the investigation of the pressure at the valve end will give a series of values of s which may be applied throughout the length of the line as indicated in (19) or (20). To this end there is needed a general history of s on time and this may be most conveniently laid down graphically from the results derived for the valve end. With such a graphical history of s the determination of h for any point in the line and at any time becomes through (19) and (20) a matter of simple routine.

Valve Opening.—The treatment for the case of valve opening is implicitly contained within that for closure, and it is only necessary to note certain special interpretations in order to apply in full the equations for the case of closure to that of opening. The change of head is now a decrease instead of an increase and is therefore essentially subtractive instead of additive. The change in velocity will be reversed in direction. That is, $s = v - v_o$, where v_o = the initial velocity through an initial opening m_oA, and if the movement starts from complete closure we shall have $s = v$.

With this value of s and all other terms in (13), (14) and (16) the same, we derive results as follows:

$$h = -(E + F) + \sqrt{F^2 + 2F(H + E)} \qquad (21)$$

where $E = \alpha(v_o + B)$, $F = \dfrac{(\alpha m)^2}{2M}$ as before and $\alpha B = h_1 + \alpha s_1$, as before.

If again the valve movement starts from full closure we shall have $v_o = 0$ and $E = \alpha B$.

These equations represent, for the case of valve opening, the same degree of generality as in the case of closure, and in particular with reference to friction, loss of energy through valve and time rate of valve movement.

Turning to equation (21), it is readily seen that the terms under the radical form two terms of $(F + H + E)^2$. In the case of valve opening, F continuously increases and in cases where the valve opening is nearly the full size of the pipe and H is small, F may be large compared with $(H + E)$. In such cases the value of the radical will be approximately $(F + H + E)$ and hence $h = H$ (actually slightly less). Hence as F becomes large relative to $(H + E)$ the value of h will approach H as a limit. This corresponds to the well known result that in cases of large valve area relative to pipe and small head H, the opening of the valve within the time z will drop the pressure at the valve practically to the atmosphere.

In the application of these equations, it will be noted that (18) or (21) gives the solution for any value of m within the time $t = z$, independent of the quantity B and hence independent of the solution for any other or previous time. If, however, $t > z$ the solution must be made step wise with a time interval z, beginning at a time $(t - nz)$ less than z itself and for which B is not required, and progressing step by step to the given value of t. Any one solution will give the values of h and s. These from (9) will give the value of B for the next step ahead and this, with the appropriate values of the other quantities, will give values of E and F and hence of h, as in (18) or (21).

Up to the present time no solution seems to have presented itself permitting the direct computation of h for $t > z$, without in effect going through the series of computations involved in the stepwise process outlined above. All this is indeed well known and has been pointed out by other writers on the subject, notably Allievi.

The purpose of this section of the present paper, omitting discussion of the resulting equations, is simply to generalize the treatment of earlier writers with reference to the four restrictive conditions (2), (3), (4), (5), as noted previously.

PARTIAL OR INCOMPLETE REFLECTION AT VALVE

We now approach the problem of generalizing the treatment in such manner as to include the assumption of partial or incomplete reflection at the valve. First with regard to the conditions affecting the assumption of complete reflection. Physically this requires a closed end, similar to the closed end of the organ pipe and against which the pressure changes may develop as required by the physical phenomena assumed. It implies furthermore complete arrest of the moving column of water, a condition not consonant with the movement of the column attendant on a flow of water through the valve while partially open.

It is clear, however, in the case of closure, that if the entire valve movement is completed within the time z, the phenomena at the valve itself, up to complete closure, will take place without involving reflection at the valve, and that all subsequent phenomena will develop at a completely closed end and hence the assumption of complete r flection is justifiable, at least so far as complete closure of the valve is concerned. It results for valve closure that whenever the time T of valve movement is not greater than z, the assumption of complete reflection may be justified by the presence of a closed end at the valve. On the other hand, it is clear that when T exceeds z, as is more often the case, the return wave from the free end will reach the valve with the latter partly open and with water issuing therefrom. Under such circumstances reflection from the valve end cannot be complete. In the general case, as we have seen, we shall have a series of waves formed at the valve, propagating to the free end and then back to the valve, undergoing reflection there and so on—new waves joining with waves which have suffered 1, 2, 3 ....n reflections back and forth, the net result at any point being the entire summation of the individual results of all elements, direct and reflected; and much of this reflection at the valve and realized while the valve is partly open and with water issuing.

It is therefore clear that the assumption of complete reflection at the valve is not justifiable in the general case, and its incorporation as a basic principle in the treatment of the problem will therefore give results which must be viewed simply as representing ideal or limit conditions, and to which actual cases will approximate as the conditions for complete reflection are more and more fully realized.

In the development of a mode of treatment free of this particular assumption, the first difficulty met with lies in the definition or measurement of partial reflection. Complete reflection is a definite and specific condition; partial reflection may be anything from 100 per cent to zero and distributed in any manner through the valve movement.

There are at least four assumptions which may be taken as a basis for the specification of partial reflection, as follows:

(1) A constant fraction of full reflection.

(2) A fraction of full reflection measured by the ratio $(m_o - m) / m_o$. That is, reflection in proportion as the valve opening is reduced in area from full opening to closure.

(3) A fraction of full reflection measured by the ratio $(A - a)/A$. That is, reflection in proportion as the cross section area of the pipe A is closed over at the valve end.

(4) A fraction of full reflection measured by the ratio $(v_o - v)/v_o$ for closure or by $(v_1 - v)/v_1$ for opening. That is, reflection in proportion to the difference between v_o or v_1 and v, or reflection less as v is greater. In the above, v_o and v_1 denote the normal steady motion full opening velocities in the two cases, closure and opening.

We shall briefly indicate the results as developed from these various assumptions regarding the degree of reflection realized.

In the development of the treatment, we shall, where there is any distinction to be drawn, assume first the case of valve closure, noting subsequently such changes as may serve to adapt the same treatment to the case of valve opening.

Case (1) Let f denote the constant fraction. Then equation (5) will become

$$h = \alpha [s - (1 + f)\, s_1 + f\,(1 + f)\, s_2 - f^2\,(1 + f) s_3 + \text{etc.}] \ldots (22)$$

The second term represents at time t an unloading s_1 + a reflection fs_1. The third term develops first at time $(t-z)$ as an unloading s_2 with reflection fs_2 and then at time t as a second unloading fs_2 with second reflection f^2s_2, giving by the sum of the two latter the term as written; and similarly for subsequent terms.

Denote all terms in the parenthesis after the first by B we then have

$$h = \alpha\,(s - B) \ldots (23)$$

With the makeup of (22) we then readily find, in manner similar to that followed with full reflection, the following relations

$$h + fh_1 = \alpha\,(s - s_1) \ldots (24)$$

$$\alpha B = fh_1 + \alpha s_1 \ldots (25)$$

It will be noted that these equations all reduce to the forms for full reflection, as in (7) (8) (9), if we put $f = 1$. We may then proceed, exactly as indicated for full reflection, using equations (17) (18) but with the value of B as in (25).

Case 2: We shall in this case have for f a varying value given by $f = (m_o - m)/m_o$. There will be, therefore, a value for each instant of time during the closure, and in particular a series of values for the instants t, t-z, t-$2z$, etc. These we may denote by f, f_1, f_2, etc. the same as for the series of values of h, s, etc. We shall have, then, instead of (22) the equation

$$h = \alpha[s - (1 + f)\, s_1 + f_1\,(1 + f)s_2 - f_1 f_2\,(1 + f)\, s_3 + \text{etc.}] \ldots (26)$$

The second term represents at time t an unloading s_1 plus a reflection fs_1. The third term develops first at time $(t - z)$ as an unloading s_2 with reflection $f_1 s_2$ and then at time t as a second unloading $f_1 s_2$ with second reflection $f f_1 s_2$, giving by the sum of the two latter the term as written; and similarly for the other terms.

Denote, as before, everything within the brackets after the first term by B. Put also

$$P = s_1 - f_1 s_2 + f_1 f_2 s_3 - \text{etc.} \ldots (27)$$

Then $P_1 = s_2 - f_2 s_3 + \text{etc.}$

Whence we derive

$$P + f_1 P_1 = s_1 \text{ or } P = s_1 - f_1 P_1 \ldots (28)$$

We have then for (26)

$$h = \alpha(s - B) \ldots (29)$$

and from the composition of (26) (27) it is seen that

$$B = (1 + f)\, P \ldots (30)$$

We also readily derive the relation

$$h + h_1 = \alpha s - f s_1 - P_1\,(1 - f f_1) \ldots (31)$$

It will be noted that (26) and (31) reduce to the forms for full reflection if we put $f = 1$.

We may now proceed as described for the case with full reflection finding h from (18) with the value of B as given by (28) (30).

Case 3: In this case the resulting fundamental equation is the same as (26) for Case 2 but with different values of f, f_1, etc. we shall have here:

$$f = \frac{A - a}{A} = 1 - \frac{a}{A} = (1 - m) \ldots (32)$$

With a prescribed program of movement for the valve, therefore, f becomes known for any instant of time and we may then use the equations of case 2 but with the appropriate values of f.

Case 4: In this case we have for valve closure

$$f = \frac{s}{v_o} \quad (33)$$

and hence for the series f, f_1, f_2, etc. we shall have s/v_o, s_1/v_o, s_2/v_o, etc.

We may, therefore, use the same general equations as for case 2 except that in this case we do not know, for any given time t, the value of f, since this depends on v and this in turn on u or h. This implicit relation does not, however, introduce any new variable into the equations and we proceed by taking equations (13), (14), (16) with the special values of B and f as given in (30) and (33). From these equations, and substituting for s in terms of v, we eliminate v, u, and s, and derive, as before, an equation in h.

$$h = (E + F) - \sqrt{F^2 + 2F(H + E)} \quad (34)$$

where $E = \alpha(v_o - 2P)$ and $F = \frac{(\alpha m)^2}{2M}\left(1 - \frac{P}{v_o}\right)^2$, the same in form as in the previous cases, and differing only in the values of E and F.

Valve Opening with Partial Reflection.—The preceding discussion, with the equations developed, applies without change to the case of valve opening, except that in Case 2 the value of f will be $(m_1 - m)/m_1$ where m_1 is the ultimate value of m, while in case 4 we shall have:

$$f = \frac{(v_1 - v)}{v_1} v_1.$$

Where v_1 = ultimate steady motion velocity with $m = m_1$

$$E = \alpha(v_o + 2P),\ F = \frac{(\alpha m)^2}{2M}\left(1 + \frac{P}{v_1}\right)^2.$$

Basis of Estimate for Degree of Partial Reflection.—As between these four bases for estimating the degree of reflection realized, we have little experimental evidence as a guide. There is no reason for assuming a constant value of f, but a constant value somewhat less than 1 would presumably give more accurate results than to assume it constant at 1, as with the assumption of complete reflection.

For a case where the open valve area is the full size of the pipe, assumptions 2 and 3 become the same, and in such case assumption 4 will differ widely from these in the values of f through the period of closure. For a case where the open valve area is small relative to the c. s. area of pipe, assumption 3 will imply practically complete reflection, while in such case assumptions 2 and 4 will more nearly agree.

Motor Car Regulation in England

Several new regulations for the control of traffic are being considered by the taxation and regulation of road vehicles committee of the British Ministry of Transport. It is believed by some that, should the proposed regulation be determined upon, making it compulsory for a driver to raise his arm when stopping, turning a corner, or slowing down, it will have some effect upon the design of motor vehicles through the elimination of the left-hand drive machine. The advisability of continued manufacture of left-hand drive cars is a subject of considerable argument in England. Another possible regulation soon to be put into force in England is the one making it possible for motor car owners to secure quarterly licenses at 30 per cent of the annual license. This regulation is to be put into force, because of the presence in England of a great number of British colonials who buy their cars in London and use them for a few months and then take them home with them. The payment of the total annual license fee for a few weeks' use in England is considered unfair.

Retaining Wall Failure Predicted

By C. W. Cook
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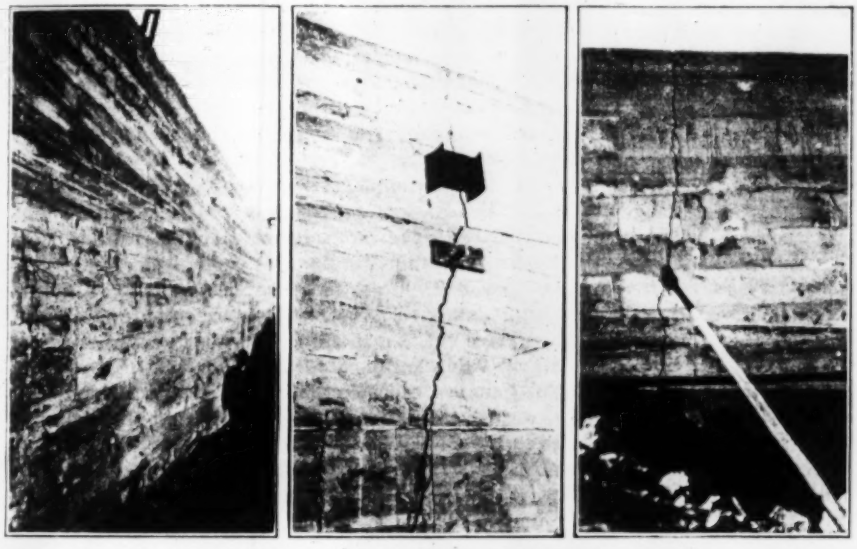
THIS is written to predict the failure of a retaining wall which has just been finished on the northwest corner of Sixth St. and Vermont Ave., Los Angeles. The drawing (Fig. 4 herewith) shows the wall as designed and as built; three views showing its condition before any large amount of backfill had been placed are given as Figs. 1-3.

At *A* in Fig. 4 is represented the original design of the wall, prepared by a firm of engineers in Los Angeles. The wall is 32 ft. 6 in. high above the ground at the high point, and was designed to be 10 ft. below the ground. Its base width is 3 ft. 6 in., this width continuing up to the surface of the ground, whence it decreases to a thickness of 1 ft. at the top. The site is a marsh, and has standing water in it all the year round. The soil is clay and loam mixed, saturated with water.



FIGS. 1, 2 AND 3. WALL CRACKED BEFORE BACKFILLING
Front of wall—Crack in face—Anchor rods

According to the original drawings of the engineers, a fill was to be put in back of the wall, 21 ft. 3 in. deep, to be surfaced with a cement floor. At the level of the top of the wall there was to be built a reinforced-concrete roof, the 12 x 30-in. beams of which frame into the wall at intervals of 21 ft. 5 in. The space under the roof was to be used as garage, with 150 lb. per sq.ft. designed live-load.

The wall itself weighs 15,550 lb. per lin.ft., and the roof weight is equivalent to 610 lb. per lin.ft., making a total dead load of 16,160 lb. per lin.ft., which acts with an eccentricity of 0.39 ft. The dead weight alone would cause a pressure at the toe of 7,700 lb. per sq. ft.—on a wet clay swamp upon which it would be unsafe to assume a unit pressure of one-half ton! Considering the 150-lb. live load (and still neglecting the fill) this pressure would become 8,350 pounds.

Computing the pressure from the fill at 25 lb. per sq.ft. equivalent fluid pressure (which is low for this case) and neglecting the 10 ft. below grade, the horizontal pressure against the wall would be 4,500 lb. per sq.ft., applied at a point 7 ft. 1 in. above the original grade. Assuming that the roof beams would hold the top of the wall (which is very unlikely since the settlement would be very great and the end of the beams would probably shear off), the wall would act as a simple beam, and having no steel in it the concrete would have to take all the tensile stress, which is about 210 lb. per sq.in. and which would undoubtedly break the wall in tension.

Disregarding the restraint at the top, the resultant of the horizontal pressure and the weight of the wall would fall about 3½ ft. outside the base, which would cause a tremendous pressure on the base and undoubtedly would turn the wall over.

When the wall was finally built the original architect and engineer had been discharged, and the work was done by another man who is a contractor and builder. He drew an entirely new set of plans for the main part of the building, but kept the design of the retaining wall as originally planned. So the original engineers are not now connected with the work.

In the revised plans, the owner decided not to build the concrete floor shown at *A* in Fig. 1, but to continue the fill up to the top of the wall and simply lay a 4-in. cement floor with no steel in it at the level of the top of the wall, as shown at *B*. The completed wall looked so slender and high, however, that the owner decided to put in some anchors. So he drilled holes through the concrete and put in 1¼-in. rods at varying spacing from 12 ft. to 15 ft. apart horizontally, about 4 ft. 2 in. from the top of the wall. They were anchored to a deadman, a block of concrete about 4 ft. cube, but this was apparently placed in front of the angle of repose of the material and was therefore of no value.

In excavating for the lower portion of the wall it was necessary to build dikes to keep the water out, and in addition pumps had to be kept going continually. The excavation was made about 2 ft. wider than the wall, and forms were built for the concrete, the remaining space on front and back being backfilled with the material taken out.

The pressure caused by 32½ ft. of fill (neglecting a surcharge to provide for the live load) would be 13,200 lb. per lin.ft., applied at a point 10 ft. 10 in. above the original grade. In analyzing this wall, moments must be taken about the toe, as the backfill of the trench cannot hold the wall. Taking moments at the toe, the overturning moment would be 13,200 x 20.83 = 275,000 ft.-lb. The righting moment would be 15,550 x 1.36 = 21,100 ft.-lb., leaving an overturning moment of 253,900 ft.-lb. If this was to be taken up by the rods, whose arm is 38.33 ft., it would cause a reaction at the rods of 6,130 lbs. per linal foot of wall, or, assuming the rods 12 ft. apart (some of them are 15 ft.) would cause a tension in each rod of 73,500

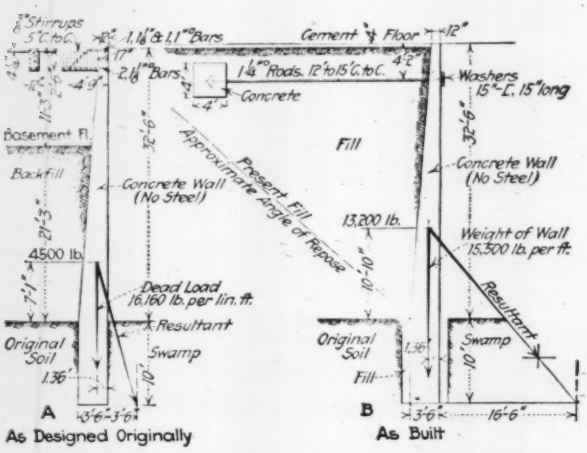


FIG. 4. A "RETAINING WALL" BUILT IN LOS ANGELES
As designed and as built.

lb. This is equivalent to 82,600 lb. per sq.in. at the root of the threads. Some of these rods have been welded, with an apparent efficiency of weld of about 50 per cent. Channels 15 in. deep and 15 in. long, with the flanges vertical, were used for washers.

Photograph Fig. 2 shows a settlement crack through two of the anchor rods. This crack extends from the top to the bottom of the wall and is about ¼ in. wide. This view also shows the channel washers, with flanges parallel to the crack. Fig. 3 shows another settlement crack from the inside of the wall, also the 1¼-in. rods with their ends forged into hooks.

As yet none of the backfill bears against the wall. All of the cracks have been caused by the settlement of the wall due to its own dead weight. The dirt is being dumped in from the rear and allowed to fall toward the wall on its own angle of repose, which exerts maximum pressure against the wall. The owner says that he intends to soak the fill with water as he puts it in, to insure it packing solidly.

In the opinion of the writer the wall will turn over before the fill is halfway up to the top. It will probably bend the channel washers out and allow a whole section of the wall to fall out, leaving the rods where they are now. As it begins to fall it will probably break in tension at about the level of the original soil.

This wall is not a part of the building, being designed only to hold a fill of earth to make a yard in back of a garage and therefore does not come under the jurisdiction of the Los Angeles building department. It does not support a part of a street and therefore is not checked by the street department. It has not been checked by anyone except the original engineer. The writer is not connected with the work in any way, being interested solely because of the very apparent weakness of the wall. He has told the owner that the wall will not stand up, and has warned him not to allow men to work on the outside of the wall. The approximate cost of the wall is $7,000.

The Itinerant Engineer

Records of the change of address made by members of the American Association of Engineers indicate that four engineers out of 10 move in the course of a year. During November, the month on which the estimate is based, 802 changes were recorded. The daily average was 32; varying from 12 to 66.

Trend of Highway Development —a Survey

Kansas Practice

THIS IS THE SEVENTH *of a series of staff articles on the highway situation. It deals with adaptations of pavement design to permit utilization of native materials and the development of laboratory investigations of these materials.*

The eighth articie of the series will appear in next week's issue.—EDITOR.

KANSAS, by an amendment to its constitution this year, completed the list of 48 states which in some manner extend financial aid in highway construction; in other words, every state in the Union now aids highway work. The campaign by which this amendment has been fought through against both popular and, in instances, corporation opposition perhaps deserves record as the outstanding feature of the year in the highway development of Kansas. It is notable, however, that the state has an exceptional mileage of paving under construction and contract, is developing interesting practices in brick and concrete construction and is conducting material tests and investigations of exceptional character.

Until the amendment was voted at the election of Nov. 2, the Kansas constitution prohibited state road construction. The amendment adopted enables the state to grant aid not in excess of a quarter of the cost, or of $10,000 per mile, for not more than 100 mi. in any county. There is but on exception: it extends the mileage entitled to aid to 150 mi. in counties whose assessed valuation exceeds $100,000,000. Provision of legislation for executing the new constitutional privilege awaits the action of the coming State Legislature. As the thought of highway officials is at present being expressed it favors raising the money for state aid by levying a tax of 1 cent a gallon on all gasoline, and by an increased license fee on automobiles. Two other methods, one a mill tax on all property and the other state bond issues, are open for consideration.

PRESENT PROGRAM

Passing from speculation on future highway programs to actuality, the important fact to be noted is that Kansas, through county and benefit-district initiative, has approximately 300 mi. of paved road under construction and contract. Projects have been scheduled absorbing practically twice the Federal-aid funds available for the state, and contracts have been let, as of October, 1920, absorbing $3,681,000 of Federal aid, and aggregating a contract cost of about $9,575,000. Without state aid and with a state highway department organized only since April, 1917, and inadequately financed, the figures are a record of accomplishment which merits recognition.

Concrete and brick on concrete base are the preferred types of paved roads. About two miles of concrete to one mile of brick are being constructed. The paved width is ordinarily 18 ft., but occasionally a 16-ft. or a 20-ft. project is listed. Selecting Federal-aid projects for 18-ft. pavements, a compilation gives the approximate costs per mile for 53 mi. of brick road as $42,000 and for 93 mi. of concrete road as $40,000 per mile.

As in most states where lack of materials has been assumed, surveys in Kansas have shown greater resources than were anticipated. To utilize these materials, modifications from fixed practices must be developed. Materials studies and tests directed toward this purpose are a salient line of development in Kansas.

In the beds of the Kaw and the Arkansas Rivers and their tributaries there is gravel running high in good quartz sand but low in pebbles; the latter, moreover, contain a considerable proportion of disintegrated granite undesirable for concrete wearing surface. Except for some isolated "flint hills," the main rock deposits are limestone of not very good quality. The state, however, has a source of imported stone supply in the chats of the Missouri mining districts, but transportation makes this material rather expensive. As a result of these materials conditions, attention is being directed toward two-course concrete construction, using native materials for the base course and imported chats for the surfacing. Using a finishing machine, the base course is struck off and the top course placed and tamped. Observation of sections cut from slabs constructed in this manner indicate (1) a nearly perfect merging together of the two courses and (2) a well-defined mortar surface layer ¼ to ½ in. thick.

Brick pavements in Kansas have been mostly of monolithic construction, using "vertical fibre" brick. Failure of one of the earlier roads of this type, as described by M. W. Watson, state highway engineer, in *Engineering News-Record*, Sept. 23, 1920, p. 595, has led to distrust of monolithic construction under the extremes of Kansas temperature. One of the characteristics of the failure described was a separation of the brick surface from the concrete base. A change in construction to meet this danger has given some success in Reno County as will be described in a separate article. Meanwhile, attention is being directed to the use of a bituminous sand cushion and bituminous filler, and the outcome is promising. Sand mixed with 5 per cent Tarvia is producing a sand cushion which will stay where placed.

Studies of Materials

Laboratory investigations of the suitability of native materials for road construction is a noteworthy feature of Kansas highway development. This work is being done at the engineering experiment station of the Kansas Agricultural College. A brief survey permits the following enumeration of work under way and planned:

1. Southeastern Kansas has available large quantities of chats or tailings from the lead and zinc mines. This material is used to a greater or less extent for construction of all kinds, but not always with good results. Tests are being made to determine whether or not this material can be satisfactorily used for highway construction.

2. The Arkansas River valley is rich in excellent gravel for concrete aggregate and has very little stone suitable for highway construction. Tests are being made to determine the ideal mixture, with the natural run of the material, which contains an excess of sand.

3. In some of the counties in the southwestern part of the state there are beds of "gyp" or "mortar bed" that has excellent binding properties. Tests indicate that this material should make a binder superior to clay or stone dust, as it is very resistant to the softening action of water. In combination with the river and pit gravel this should make very good material for roads of the secondary type.

4. A test is being developed to determine the relative wearing value of stone and gravel.

5. The laboratory has developed a test for the wearing value of concrete that is original and, it is felt, has given encouraging results.

New Test Specimen

Briefly, the new test (item 5, above) consists in molding 9-in. spherical specimens of the desired mix. These are tested in the standard brick rattler, using three specimens at one time and a standard abrasion charge. The results so far secured are not conclusive but have demonstrated the practicability of the test. No difficulty is encountered in molding the specimens or in securing a smooth wearing surface to take the abrasion. There is no tendency for the specimens to break or go to pieces in the rattler when tested at 28 days. It is thought that tests at an earlier age should not be made. The time required for a test seems to be about ½ hour, as the loss in nearly every case is great enough at 900 revolutions to make comparison of different specimens possible. The specimens have thus far been molded in concrete forms which were cast around a wooden ball and later paraffined and oiled. The really original feature is the use of a spherical test specimen. Two advantages over other abrasive test specimens are that the spherical surface offers no angles or curves to be broken off, and that no special equipment is required for the test, as the standard rattler may be used.

With the enactment of the constitutional amendment state-aid legislation is the important highway development of the coming winter.

Effect of Hard Inclusions in Spruce Compression Members

Some observations on the effect of hard inclusions in compression members on ultimate strength were made by Prof. James E. Boyd, Ohio State University, in the course of tests of the strength of spruce struts carried out for the Bureau of Standards. The tests are described in Technologic Paper 152 of the Bureau, recently issued. All the struts tested were 1⅜ to 1⅝-in. square, while their lengths varied from 12⅜ to 10 ft. 6¼ in. (1/r from 25 to 250). To measure the shortening of the struts, strain gages were applied, their ends resting in conical pits in ¼-in. steel pins driven through holes drilled in the struts. The effect of these pins on the failure strength of the struts came to attention by the fact that most of the struts of the 1-ft. and 2-ft. lengths failed by compression at these pins. It was thought, therefore, that a cylindrical pin with higher modulus of elasticity than the material which surrounds it is a source of weakness in a compression member. To investigate this question two of the shortest struts were tested without pins, the strain gages being supported by clamps. Each of these two struts failed at a lower load than the struts from the same plank which had been tested with pins. Professor Boyd concludes that "if any conclusion may be drawn from these few tests it is that the pins do not seriously weaken the struts."

Observations on a Pacific Coast Trip

By Frank C. Wight
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Vancouver and Its British Flavor

THE national spirit is a great and curious thing. At the foot of Yesler Way in Seattle lies a boat flying the British flag. You pass down that street, a typical waterfront entrance in a distinctly American city, where the signs and the talk and the whole flavor of things are as familiar to a native of Chillicothe or Omaha as his own town, and you walk across a gang plank into a little section of Great Britain. From then until you get off that boat some days later when it comes back to Seattle, to all intents and purposes you are in England. The ship's officers, with the characteristic tilted cap, the cockney waiters in the dining saloon, the Clyde-built engines—and even the American-baiting Canadian who rails at the dollar-chasing Yankee in the sheltered space behind the pilot house—are part of the essence that sends a little island's sons across the seven seas to set up in the world's far places a part of its great dominion.

For an hour the boat stops at Victoria, the farthest west of the Canadian capitals, and the remoteness of the States is more than ever emphasized, for here at the seat of Provincial government the British spirit is plain in the things that appeal to an engineer. The massive masonry sea-wall guarding the inner harbor, in particular, came straight from the craft which designed and built the ports of England; its like is not found in our more practical, and possibly ephemeral, practice. The new breakwater, with its concrete blocks, looks familiar, though, and the huge new government piers, wide, long and with equally wide and long transit sheds, show the trend of Pacific port design; also, there are emptiness and signs of disuse, which indicate that the slump in Pacific shipping is not confined to American ports.

Vancouver, a day's journey by boat from Seattle and only a few miles across the border, adds to the feeling that one is far from home, especially as it still sticks to left-hand running of street traffic, to the imminent danger of life and limb of the American used to looking to his left at street crossings. The nearness of the state of Washington, however, with the ever increasing cross-border automobile travel, has led the province to pass a law requiring change to right-hand running at an early date. Like Halifax, Vancouver is more truly British than the inland Canadian cities, where dilution of American-born residents is beginning to show. The Canadian termini of the "all-red" British steamship lines stick closer in habit and custom to the old country.

The Port

Economically and industrially, Vancouver is a part of the great Northwest. Conditions here are about the same as in Seattle. During the war the focus of England's oriental trade and a shipbuilding center, it suffers now from the cessation of war business.

Lumbering and mining are its big industries and the former particularly is flourishing. To one long accustomed to the structural timber of the East the kind of material they get here is amazing. It is a pleasure to look at the great clear sticks that go into the sheds and floating dry docks. Such wood, properly framed, is a structural material of lasting quality which can well compete with what we generally consider more durable stuff.

But lumbering and mining are not enough to make Vancouver the great city it wants to be. It must get more shipping business and must develop the industries which go hand in hand with a harbor to make a city a successful port. Its bulk shipping is large—the largest in tonnage last year in Canada, though Montreal's values passed it—but not so much is moving this year. The Harbor Commission is going ahead actively, though, and work now in progress is greater than anywhere else in the Northwest.

This work comprises in actual construction two large shipping piers and a graving dock. One of the piers is being built by the commission—the Ballantyne Pier. This is on the main harbor front, a little more than a mile from the center of town. It is 1,200 ft. long and 340 ft. wide with a marginal quay wall 936 ft. long. It will be built with a middle fill and side extensions on reinforced-concrete cylinders and will carry two-story reinforced-concrete transit sheds on either side, each 110 ft. wide. Following the practice on the existing government wharf, which has approximately the same dimensions, there are marginal railway tracks and also tracks and a roadway between the sheds. The other pier is being built close to the center of town by the Canadian Pacific Ry. and will be 1,100 ft. long by 330 ft. wide with 335 ft. slips. Work on it at present consists only in placing the middle fill and its final design has not been announced, but it will probably be similar to the Ballantyne Pier. The dry dock is a private enterprise, with a 12½ per cent subsidy from the Canadian Government and will eventually be 1,150 x 110 ft. in plan, but at present will be built only to a length of 800 ft.

In addition the Harbor Commission is developing a sizable industrial area in one of the creeks making in from the harbor and is studying the development of a larger one farther down the creek. At present the various railways reach the wharves so that rail connections is assured, though somewhat complicated, but plans are under way for the construction of a government terminal belt railway.

Vancouver is blessed with the most picturesque natural harbor on the Pacific Coast—a perfect refuge among mile-high mountains. Its man-made harbor requirements are being advanced with a reasonable and judicious speed.

One thing here is common to all these Northwest ports. The large grain elevators are empty. Of course the farmer is holding his wheat for better prices, but the more knowing say that even when the wheat moves ships cannot compete with the railroad for European wheat shipments. The big wheat country is far enough east so that rail rates are sufficiently attractive to draw the grain to bottoms in Atlantic ports. Beside that, the Europe-bound ships these days have little to bring back and only return-cargo business pays. At any rate at Portland, Seattle and Vancouver there are many millions now tied up in huge concrete grain elevators that are lying idle.

Although Vancouver is far north it is not a freezing country so that the concrete in the port works has only to stand the sea water. So far it is in very good condition, and has not shown any of the destruction which is reported so common farther down the coast.

The teredo and his smaller relatives are active, though, and timber below water is uniformly creosoted.

Hydro-electric power development is of course talked about, but as yet little new work is being done. One big scheme only 120 miles from Vancouver and with a power house site right on a railroad is being held from publicity until certain rights are obtained. It has a remarkable natural advantage—a 4,000-sec. ft. river, 1,200 ft. above and only two miles away from another river, which can be reached by an easily driven tunnel and on which the power house can be located. Plans are now being made to develop 50,000 hp. in two units. Particular interest attaches to such developments because of the oil shortage. Oil contracts are now being written only on a short-time basis, with no prospect of bettering conditions. In fact, the Canadian Pacific is now engaged in transforming all of its coast-division locomotives from oil to coal burning. This condition prevails all down the coast and steam power houses are being converted to a coal and hogged-fuel basis. This hogged-fuel—the wood refuse from saw mills—is very effective but requires exceptionally good transportation and loading conditions because of the rapidity with which it is consumed. In view of current eastern discussions on the steam versus the electric locomotives it is surely pertinent to record the conditions in a country where coal and oil are both hard to get and where, of course, for the locomotive hogged-fuel is out of the question.

Industrial development in British Columbia must of necessity be in its infancy. The province has approximately 400,000 square miles and 400,000 inhabitants. Of this huge area 99½ per cent is unorganized and has only 14 per cent of the population. Consider, for instance, the financial difficulty of building roads and railroads through such a country. So far only the surface has been scratched, the main routes cut through; there are only 1½ miles of road per capita and ¾ mile of trail. The burden of cost must necessarily fall on the cities and unfortunately they have been over extended. That curse of the Northwest—the real estate shark—has gotten in his deadly work and the towns and cities are already staggering under a debt burden due mostly to unwarranted development of municipal area far beyond the needs of the population.

Municipal Over-Extension

From a test section of Vancouver, for instance, it was found that a population of twelve to the acre could hardly pay the necessary charges for the construction and maintenance of municipal necessities. Yet in the adjoining city of South Vancouver, the multiplication of subdivisions and the extension of remote sections farther and farther out, to escape the rising prices of the partly settled districts, has resulted in an average population of three to the acre. In consequence South Vancouver has gone into the hands of a receiver! It could not meet its obligations and to protect the credit of its other municipalities—which naturally would suffer in the bond markets—the Province of British Columbia has taken over South Vancouver's liabilities. It has established there a representative who virtually runs the city and will probably continue to do so until conditions become normal.

Vancouver itself is of course in no such dire plight. It is better managed and more prosperous, but even so one of the Dominion authorities recently stated that "streets and building sites have been laid out in the districts immediately adjacent to Vancouver alone which would provide for a population half the size of the present population of the whole Dominion." Such extensions demand improvements, which political exigencies often supply—and the city's credit steadily grows less. Wide and open spaces are necessary to health and happiness. Out here in the mountains and the woods and by the open sea men expect them, but too high a price can be paid. Intelligent planning of city development and the curbing of the real estate promoter are necessary to the right upbuilding of a city and its industries. In British Columbia these facts are being realized and the city-planner—an economist and an engineer, not a landscape gardner or a "prettifier"—is apt to come into his own in the near future.

This over-extension is doubtless no greater in Vancouver than in many other Coast cities on both sides the line, and that it has been recognized here argues well for the future. For Vancouver—though a Canadian and as has been intimated a British city—is a part of the great Northwest and moves up or down with the whole section. Just now it is sitting tight and waiting to see what is going to happen—but in that it has many companions not only on the Pacific but the country over. It is the terminus of two transcontinental railways and it has one of the great natural harbors of the world. Ordinary prudence will insure its growth, and to that is being added a sound engineering foresight which is gradually developing the city's resources in a satisfactory manner.

Big Tidal Power Project Announced in England

Ministry of Transport Plans to Dam Severn River and Install Turbo-Generators to Produce 500,000 Hp.

UTILIZATION of the tidal flow of the Severn River in England to produce electrical energy estimated at 500,000 l.p. for industrial purposes is proposed in plans, involving the construction of a reinforced concrete dam across the stream below Chepstow and the installation of turbo-generators, which were made public a few weeks ago by the Ministry of Transport. One of the novel features of the project is the proposed use of surplus power for pumping to a high-level lake water which will be allowed to flow back through turbines during periods of high tide, thus maintaining a continuity of electrical supply regardless of the procession of the tides. The head of water under which the main turbines will operate varies from 5 to 30 ft. The following notes regarding the project, which has been planned by Sir Alexander Gibb, J. Ferguson and T. R. Menzies and is estimated to cost, according to published "guesses," between £8,000,000 and £30,000,000, are from an article in the Dec. 3 issue of *The Engineer*, London:

The power available in the Severn by reason of the ebb and flow of the river is largely in excess of all the potential sources of inland water power within the United Kingdom. It is claimed that the Severn is unique in that it possesses all the features which are essential for the economic development of tidal water power on a large scale. It has, first of all, an exceptionally high range of tide and an estuary of large capacity. Then, too, it occupies an ideal geographical situation in relation to the industrial centers of the country, while there is abundance of suit-

able land along the banks of the estuary for the further development of industry.

At the point where it is proposed to construct the dam the river Severn is about 2½ mi. wide, and the country on both sides of it is fairly low-lying. At present the greater part of the bed of the river is exposed at low water. Not far from the center of the river there is, however, a deep channel, which is known as "The Shoots."

The project provides not only for the construction of a level roadway across the dam, but also for the quadrupling of the Great Western Railway Co.'s line between the West of England and South Wales, when required, at a considerably less cost than could be achieved in any other way. By it, too, there would be provided a locked basin for shipping purposes of over 27 sq.mi., a large proportion of which would be suitable for the accommodation of ocean-going vessels of the largest size, and which would be usable at all states of the tide.

Two Separate Installations

Two separate electrical installations will be required in connection with the power scheme. First, there will be that comprising the turbines and generators on the dam, which will be in operation when the level of the water in the shipping basin is sufficiently high above the water in the estuary to enable current to be generated efficiently. It is quite evident, however, that not only will continuous working of those turbines be impossible, but that the portion of each 24 hr. during which operation will be possible will vary from day to day. Hence the need for the second installation, which will include a high-level lake, to be formed by constructing a dam across a valley leading from the Wye Valley just above Tintern Abbey. Into that reservoir water is to be pumped when surplus energy is being produced by the turbines in the dam, and allowed to escape back through other turbines into the river when the turbines in the main dam cannot operate, thus maintaining the continuity of electrical supply. No statement is made as to what is to be the elevation of the water in the high-level lake or reservoir. It is only explained that it is "high." It is stated, however, that there is to be "an immense pumping and turbine powerhouse" on the banks of the tidal portion of the Wye.

The method which it is proposed to adopt in order to utilize the power of the tides in the Severn is to trap this water in the part of the estuary above the dam at high water, so as to create an artificial difference in the level between the water thus impounded above the dam and the water in the estuary below the dam, for a period of several hours round about the period of low tide.

A feature of the proposal is that the water from the river Wye is to be forced to the high-level reservoir through a tunnel driven through more than a mile of solid rock. The tunnel is to be 40 ft. in diameter; that is to say, it will have nearly four times the cross-sectional area of an ordinary double-line railway tunnel, and will be, it is claimed, the largest tunnel of its kind in the world.

No figures are given in the official document as to the first cost of the scheme as a whole, but published guesses at it have varied between £8,000,000 and £30,000,000. It is stated, however, that the estimated cost for generation at present-day prices is a little over ½d. per board of trade unit. It is claimed that incidentally the utilization of the power derived from the operation of the scheme would effect a saving in coal consumption of from three to four million tons per year.

The principal characteristics which distinguish the tidal power scheme from a hydro-electric installation of the usual description are, first, that the power is only obtainable intermittently according to the state of the tide, and, secondly, that even while the turbines are at work the conditions of head are continually varying. In the scheme which is under consideration at the Severn barrage, the working period for the turbines occurs shortly after the ebb tide has commenced to run, and continues throughout the hours of low water and until the tide has risen to about half its height. Owing to the fact that the ebb tide in the Severn occupies a longer period than the flood tide it is possible to obtain a working period for the turbines of approximately 7-hr. duration, which is followed by the period of 5-hr. duration during which no power is obtainable. The head under which the turbines work would be to commence with about 5 ft. and toward the middle of the 7-hr. working period it would increase to a maximum on Spring tides of 30 ft.

It is contemplated to use mixed flow turbines, the runners being of 10-ft. diameter and having their axes vertical. With this type of turbine it is essential, in order to obtain the highest efficiency at every head, that the turbines should be run at a different speed for each particular head. The first difficulty, therefore, which has to be overcome from an electrical point of view is to adapt the electric generator to the varying speeds of the turbine. In the case of the Severn installation the turbines would rotate at speeds approximately between 40 and 80 r.p.m. It is proposed in this case to drive the generator through helical gearing, having a ratio of approximately 7½ to 1, and producing generator speeds of between 300 to 500 r.p.m.

Electric Equipment

The generator proposed is a direct-current dynamo of special design with a vertical axis. These machines would be separately excited with shunt characteristic. The control would be effected either automatically or by an operator controlling the excitation and load currents of the dynamos in such a way that the resisting torque offered by the dynamo would be such at any moment as to prevent the turbine from rotating at a speed greater than the theoretically correct speed for maximum output under the particular head of water which happened to prevail at the moment in question. The operator would, of course, be guided by an indicator, which would show him exactly what head of water he had to deal with at every moment. The greatest rate of change of head which is anticipated will be 10-ft. increase or diminution in the hour. Dynamos would be required to produce current at the varying speeds, but at constant voltage of 525 volts, the average output of each dynamo being approximately 1,300 kw.

The direct-current so produced would be passed into rotary converters of large capacity, which would produce alternating-current at 330 volts. Static transformers would transform the pressure up from 330 to 60,000 volts, the tension at which it would be proposed to transmit the energy.

When circumstances will permit it energy would be transmitted direct to industry from the tidal turbines. At such times, however, as the tidal turbine installation was producing a greater amount of power than that which could be absorbed by industry the residue of the power would be transmitted a distance of about 10 miles up to the storage reservoir, where it would be made use of to drive motors, which, in turn, drive centrifugal pumps to force water up the 40-ft. diameter tunnel into the high-level lake.

The motors which it would be proposed to make use of would have a speed of about 375 r.p.m., working at 2,200 volts and each having an output of about 13,000 kw. The type made use of would, in respect of 90 per cent of the motors, be induction alternating-current motors, and in respect of the remaining 10 per cent synchronous alternating-current motors. The induction motors would be used as being cheaper and more easily paralleled. The purpose of the synchronous motors is to keep up the power factor when they are acting as motors, and to supply wattless current to the induction machines when the whole are acting as generators. In order to save the cost of installing two sets of electrical machines at the storage reservoir it would be proposed to combine in one machine the motor for driving the centrifugal pumps and the generator, which is to be driven by a turbine at such times as when the storage reservoir is giving forth power.

Whereas the amount of energy to be derived from the tides in the Severn average week in and week out about 500,000 hp. for a 10-hr. day, it would be proposed to install machinery at the storage reservoir to give a maximum or peak output of approximately 100,000 hp.

Venturi Flume Data Throws Light Upon "Control Weir"

Drop at Throat Makes Special Case in Which Head at Upstream End of Flume Only Is Read to Obtain Discharge

By Julian Hinds
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HAVING recently completed a design for a specialized type of Venturi flume, the writer is much interested in the data on this subject presented by Messrs. Wilson and Wright in the *Engineering News-Record*, Sept. 2, 1920, p. 453. The special type of Venturi referred to has, for lack of a better name, been called a "control weir" and is in fact a Venturi flume operating with the "maximum Venturi difference." It may be of interest to outline the principles of the proposed device and to investigate the bearing of the data submitted upon its operation.

A sketch of the control weir is shown in Fig. 1. A

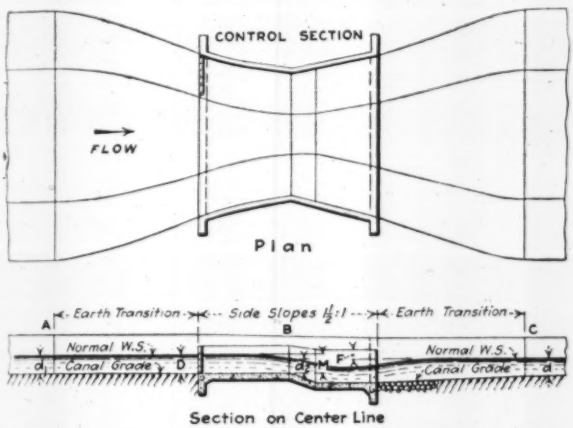


FIG. 1. CONTROL WEIR BASED ON VENTURI FLUME

slight drop is provided at B and the sides are brought in to choke, or control, the flow at that point. Theoretically, if the drop is sufficient to prevent interference from back water, the water surface at B will be "drawn down" to a definite point, and *no lower*. The corresponding depth will be that for minimum head, or minimum value of depth plus velocity head, and is called the critical depth. This depth will be independent of fluctuation in the water surface below the structure so long as the drop from A to C is sufficient to overcome the losses incidental to the operation of the weir.

It therefore follows that for a given discharge the stage at B may be computed, or if the stage is known the discharge can be found. Theoretically, the quantity of flow may be determined from the measured depth at B, but the water surface at that point is usually unsteady and may be materially altered by a slight obstruction or irregularity in the channel. For this reason the depth at B is not a reliable indication of the discharge, but the energy head (depth plus velocity head) at that point is definite and constant. By adding the estimated losses between A and B to the energy head at B the energy head at A is obtained, and from this the depth at A may be computed. Reversing the process, the depth at A may be measured and the discharge computed. The depth at A should not fluctuate unduly.

Having the depth d_1 at A, the discharge for a given weir may be computed by the formula for the Venturi flume, the value of h being determined from its known relation to d_1, but in the preparation of rating curves or tables it is more expeditious to proceed as follows:

(a) Assume depths at B and find the discharges for which these depths are critical; also the corresponding velocity heads and energy heads.

(b) Add the estimated losses from A to B to the energy head thus found to get energy head at A.

(c) Find by trial the depth, d_1, for which the depth plus velocity head at A will equal the required energy head.

(d) Construct a rating curve from the corresponding discharges and values of d_1 thus found. If tables are desired they may be constructed from the curve.

The discharge for which an assumed depth is critical may be found by taking the velocity head (hv) equal to the area of the water section (F_2) divided by twice the width of the channel at the water surface ($2T$), as expressed by the following equation:

$$hv = \frac{F_2}{2T} \qquad (1)$$

For rectangular and triangular channels equation (1) reduces respectively to equations (2) and (3) below:

$$hv = \frac{1}{2}d_2 \text{ (Rectangular Channel)} \qquad (2)$$

$$hv = \frac{1}{4}d_2 \text{ (Triangular Channel)} \qquad (3)$$

In analyzing the data tabulated by Messrs. Wilson and Wright, it was observed that in a number of cases the Venturi difference was maximum and that the flume was, consequently, operating as a control weir. Since the experimental flume was rectangular, the maximum Venturi difference, h, neglecting losses above throat and velocity head due to velocity of approach, should be approximately one third of d_1. Observations fulfilling this condition were selected and the values of d_1 and the discharge platted on Fig. 2, upon which a line showing the theoretical relation of these functions had been previously platted. The experimental points all fall reasonably close to the theoretical line.

A few points fall below the curve, indicating an actual discharge in excess of the theoretical. This is probably due to slight errors in observation. Only six such points fall below the line by an appreciable amount and all such points are for the 8 x 8-in. throat, for which the data are less reliable.

From the original tabulations it will be noticed that generally the value C_f for points below the curve is more than unity, and for points above less than unity. There are, however, certain exceptions to this, due possibly to methods of reduction used. After trying about fifteen "sets" the writer is unable to check exactly any of the tabulated values of C_f. This is undoubtedly due to the fact that the data of each set were averaged after reduction, in which case the "average data" will not necessarily give the same coefficient as that obtained from averaging the coefficients from the individual computations.

The formula for Q_f in conjunction with slightly erroneous observations, may also be responsible for part

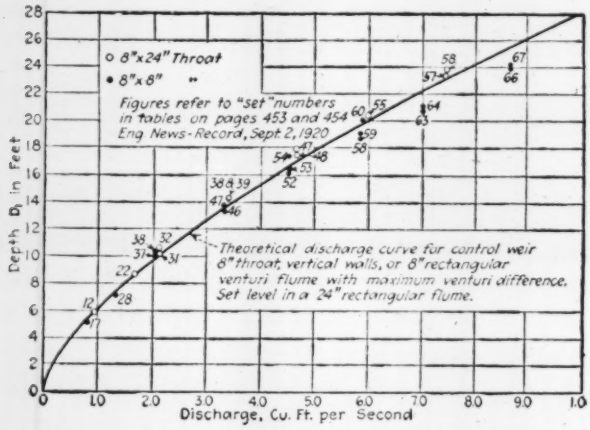

o 8"x24" Throat
• 8"x8" "
Figures refer to "set" numbers in tables on pages 453 and 454 Eng. News-Record, Sept 2, 1920
Theoretical discharge curve for control weir 8" throat, vertical walls, or 8" rectangular venturi flume with maximum venturi difference. Set level in a 24" rectangular flume.
Depth D_1 in Feet
Discharge, Cu. Ft. per Second

FIG. 2. COMPARISON OF THEORETICAL AND OBSERVED DISCHARGE FOR CONTROL WEIR AND VENTURI FLUME

of the discrepancies. In a number of cases the Venturi difference, h, is slightly greater than is theoretically possible. Such values of h, if used in formula for Q_1, will give discharges smaller than would be obtained by using the theoretical maximum values of h.

The "maximum Venturi differences" taken from the data for the 8 x 24-in. flume tend to run greater than the theoretical maximum, while for the 8 x 8-in. flume they are generally smaller. The location of the points of observation may have been partly responsible for this, and the more or less unstable condition of flow at the critical depth doubtless contributed further to the variation.

It has been expected that the loss necessary for the operation of the control weir would be smaller than is indicated by the author's Fig. 6. It is probable that these losses are somewhat increased by the proportions of the apparatus. While the side tapers appear to have been sufficiently gradual, the water surface slopes were rather steep and may have produced contractions on the top. The losses, it will be noticed, are much more marked for large flows, where the drop in the inlet is comparatively great. For irrigation or other canal work such a narrow, deep flume or control weir as that used in the experiments would seldom be desirable, since it would tend too greatly to check high flows.

When properly proportioned, the control weir should act as an automatic check, and a trapezoidal or triangular section is usually most effective for measuring a widely varying discharge. These forms are also economical for construction in concrete, since they involve no form work.

The automatic checking feature of the control weir may be secured by properly proportioning the section at B. Theoretically, the control can be designed to hold the water surface at A exactly up to normal for all flows, but practically it is sufficient to design for an exact control for two depths only, as in the design of the notched drop.

The form, size and vertical setting are the three fundamental variables affecting the section at B as a control. If only two point control is desired one of these variables, preferably the form, may be arbitrarily chosen. Suppose for example that it is required to prepare a design for a structure which will exactly control either 100 sec.-ft. or 25 sec.-ft. flowing in a given canal where the difference in normal depth for the two flows is 1 ft., using, if possible, a trapezoidal section having side slopes of 1.5 to 1.0. It is evident that by making the bottom of the control very wide the difference in the values of d_1 for the large and small flows can be made smaller than 1 ft. This difference can be increased by decreasing the bottom width, up to the point at which this width becomes zero. If still further increase is required it will be necessary to steepen the side slopes. For some width of notch the difference will be the required 1 ft., and if the floor of the control is set at the proper elevation the water surface at A will be held at normal for specified flows.

It is possible to derive formulæ from which the proportions of the control may be determined, but such formulæ generally involve transcendental functions, or are otherwise difficult to solve, and it is usually better to make the solution by trial. To do this assume a section at B, compute d_1 for the two controlling flows as directed above, and note whether their difference is equal to the required difference in normal depths in the canal. If not assume a new section and repeat the operation until the required proportions are found, and set the floor of the control to give the proper elevation of water surface at the intake.

While the automatic check feature is not essential to either it is believed that it will improve the operating characteristics of both the Venturi flume and the control weir. A discussion of the principles of the control section will be found in an article by the writer on "The Hydraulic Jump and Critical Depth in the Design of Hydraulic Structure" which appeared in the *Engineering News-Record*, Nov. 25, 1920, p. 1034.

The advantage claimed for the control weir over the Venturi flume is that it requires only a single observation to determine the discharge, this observation being taken and used in exactly the same way as for an ordinary weir. If all water measurements were taken by technical men this advantage would be slight, but the average ditchrider on an irrigation canal has had little or no scientific training, and is inclined to distrust any apparatus requiring refined or complicated observations. He understands the operation of the weir, and it is hoped that the control weir can be developed into an equally simple device, requiring a small head for operation and free from trouble due to silting up of pools.

The control weir is at a disadvantage in that it may be drowned by fouling or checking in the canal below. The elevation of the water surface at C may be increased until the fall from A to C is not sufficient to operate the weir. The water surface in such case will rise at both B and A, and the structure will cease to function as a weir. The possibility of such an occurrence should be considered before the installation of the device. If after a control weir is installed it becomes drowned from any cause and it is found impossible to remove the back water condition, a second gage may be installed at B and the structure used as a Venturi flume.

The control weir is, as yet, only in the experimental stage, and has not been submitted to practical test. A number of installations are being made, however, on the Huntley Project of the U. S. Reclamation Service and will be tested in 1921. It is hoped that these tests, combined with the data submitted by Messrs. Wilson and Wright, will serve to establish the reliability of the control weir as a measuring device, and to determine coefficients of discharge and loss.

Revised Rules on Compressed-Air Work in New York

Conference of Engineers, Contractors, Workmen and State Departments Adopts Measures for Safety of Men and Work

A REVISION of rules providing for the safety of work in compressed air in the State of New York has been adopted by the State Industrial Commission in accordance with the Labor Law, this revision having been undertaken on the advice of a committee composed of representatives of the New York State Labor Department, the Transit Construction Commission, the Compressed Air Workers Union, and tunnel and caisson contractors. A summary of the revised rules, dated March 1, 1920, is given herewith:

Working Time.—The hours of labor per 24-hr. period which are permitted for work in compressed air vary with the pressure employed, as shown in the accompanying table:

HOURS OF WORK FOR MEN WORKING IN COMPRESSED AIR

Air Pressure Lb. per Sq In.	Max. Hours of Work per 24 Hours	No. and Length of Working Periods	Compulsory Interval in Open Air Between Working Periods, Hours
0 to 22	8	.....*	½*
22 to 30	6	2 : 3-hr.	1
30 to 35	4	2 : 2-hr.	2
35 to 40	3	2 : 1½-hr.	3
40 to 45	2	2 : 1-hr.	4
45 to 50	1½	2 : 45-min.	5

* The way in which the 8-hour period is to be divided by the ½-hour interval in open air is not specified.

Decompression.—Decompression in the intermediate air lock must give a drop of half the maximum gage pressure at the rate of 5 lb. per minute, the remaining decompression being at a uniform rate and the total time being equal to that specified for the original maximum pressure as follows: For pressures up to 15, 20 and 30 lb. and over 30 lb., the decompression is to be at the minimum rate of 3 2 1½ and 1 lb. per minute, respectively.

Where the pressure exceeds 17 lb., a recording gage must be attached to the exterior of each man lock, with a dial of such size as to show readily the rise or fall in air pressure in 5-minute intervals. On the outer side of each working chamber must be at least one back pressure gage, which must be tested every 24 hours and record kept of each test Fittings must be provided also for test gages. The man in charge of the valves and gages of the working chamber must be on duty not more than 8 hr. in a 24-hr. period and must not operate more than two separate pipe lines.

Tunnels.—When the air pressure in a heading exceeds 22 lb. per square inch two air chambers must always be in use, except when starting headings from shafts. Intermediate bulkheads at a prescribed distance from the heading may be required by the Industrial Commission. Tunnels 16 ft. or more in diameter must have hanging walks from the working face to the nearest lock, 6 ft. headroom being maintained and ramps provided under all safety screens. These screens, not less than 200 ft. from the face, may be required in tunnels 12 ft. or more in diameter when the heading extends beyond the shore line.

Tunnels 12 ft. or more in diameter, or of equivalent area, must have at least two locks, one to be a man lock at least 5 ft. high and of such size that those using it are not compelled to be in a cramped position. The emergency lock must be large enough to hold an entire heading crew. Valves must be provided to enable the locks to be operated from within and without. Where the pressure exceeds 17 lb., a record of all men working in the air chamber is to be kept by a man who is detailed for that purpose and remains near the outside of the lock entrance. This record must show for each man the period of stay in the chamber and the time taken for decompression.

Each shaft must have a covered stairway 2½ ft. wide or, if this is not practicable, a ladder with landings at 20-ft. intervals of sufficient width to permit men to pass. The minimum dimensions for the ladders are a 12-in. width with rungs of 14-in. spacing and 4-in. clear from the wall.

Explosives and detonators must be carried separately, in covered wood boxes painted red, being taken at least 25 ft. apart during transportation and not carried on the same cage. When taken into the air chamber they must be kept at opposite ends of the lock, only the carriers and lock tender being in the lock. Between firing rounds, the explosives and detonators must be kept on wooden platforms 25 ft. apart, at least 600 ft. from the heading and on the side opposite to the electric light and power line. After blasting, the explosives not used are to be returned to the magazine in accordance with the same rules.

Caissons.—In pneumatic caissons all shafts must be provided with ladders and man shafts must be lighted by guarded incandescent lamps 10 ft. apart. Caissons in which more than fifteen men are employed are to have two locks, one being used as a man lock, and caissons more than 10 ft. in diameter must have a separate man shaft.

When the working chamber is less than 12 ft. in length and when such caissons are at any time suspended or hung while work is in progress so that the bottom of the excavation is more than 9 ft. below the deck of the working chamber, a shield is to be erected in the chamber for the protection of the workmen. In the working chamber all electric wires must be provided with a switch to disconnect all current before electric wires are removed or before a charge is exploded. The method of dropping a caisson by removing the air pressure must not be employed for a greater drop than 24 in., and then only by the man in charge.

Air, Light and Fire Protection.—Compressor plants must be of ample capacity to provide for emergencies and repairs, and must be capable of furnishing to each working chamber a sufficient air supply at all pressures to enable work to be done as nearly as posssible in the dry. Duplicate equipment and two or more sources of power supply are required when current for electric operation of compressors is purchased from a local plant. Duplicate air feed pipes must be provided to a point beyond the lock and to all caissons. In caisson work every effort must be made to keep the temperature in the working chamber below 100 deg. F.

Lighting in compressed air chambers must be by electricity only, preferably with two independent lighting systems having independed sources of supply. Smoking and nuisance are prohibited. Fresh air supply must be sufficient to permit work to be done without danger or discomfort. All air lines must have check valves and must be carried as nearly as posssible to the working face. The air is to be analyzed by the contractor as required, record being kept of the analyses. Fire hose connections must be provided within reasonable distance of all caissons. Tunnels must have water lines with hose connections at 200-ft. intervals, and on each side of a tunnel bulkhead must be at least 50 ft. of hose with nozzle connection.

Medical Care.—A physician experienced in compressed air work must be employed, no man being permitted to work until he has been examined and reported in fit condition. If a man is absent for ten days or more he must be examined before resuming work, and when he has worked continuously for two months he must again be examined. A man who has not worked previously in compressed air must be re-examined after the first half-day period, and where the pressure is over 17 lb. he must first be tested by the physician in the medical lock required for all work where this pressure is exceeded. When the pressure exceeds 17 lb. or when fifty or more men are employed the physician must be in attendance at all times while the work is in progress. A first-aid room must be provided, in close proximity to the medical lock. All cases of compressed air illness must be reported to the State Industrial Commission on blanks supplied for that purpose.

Petrograd and Moscow Populations Decrease

Preliminary returns of the Russian census, according to a Stockholm press dispatch, show a decrease of 71 per cent in the population of Petrograd and of 45 per cent in that of Moscow, compared with 1914.

Chicago Electrification and Elevation on C., M. & St. P. Ry.

Third-Rail Passenger and Trolley Freight Service on Evanston Suburban Line—Concrete Walls and Trestle—Precast and Poured Bridge Decks

CONCRETE cellular and gravity retaining walls, steel girder spans, bridge decks poured in place and built of precast slabs, concrete cantilever brackets to carry plank walks, a two-post concrete trestle for single track and three-post concrete trestles for double track at stations are structural features included in the track elevation work now in progress on the Chicago and Evanston Division of the Chicago, Milwaukee & St. Paul Ry. Electric operation of passenger traffic by an elevated railway and of freight traffic by the C., M. & St. P. Ry., using the third-rail and trolley systems respectively, will be an unusual combination. The track elevation is a project commenced in 1915 but interrupted by the war.

Operating Conditions—Under the joint system of operation now in force the railway company which owns the line handles only the freight traffic, all passenger service being rendered by the electric trains of the Chicago elevated railway system. The interurban

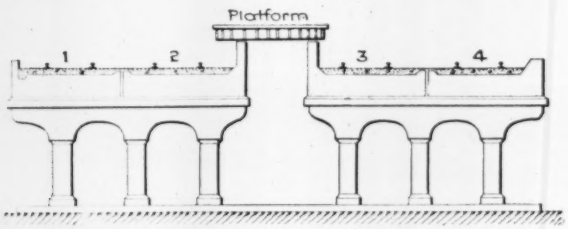


FIG. 1. TYPICAL STATION ARRANGEMENT WITH ISLAND PLATFORM AND THREE-POST DOUBLE-TRACK CONCRETE TRESTLES

trains of the Chicago, North Shore & Milwaukee Electric Ry. are also operated over this line. Originally the Evanston Division was a surface suburban line with a light service of steam trains from the Chicago union station. In 1906 the railway company leased its tracks from Wilson Ave., Chicago, to Central Ave., Evanston, to the Northwestern Elevated Ry., thus enabling the latter to extend its rapid transit service from the Wilson Ave. terminal of its line into the city of Evanston. An incline was built connecting the elevated line with the surface tracks, and the C., M. & St. P. Ry. then discontinued its passenger service north of Wilson Ave., but retained the use of the tracks for freight and switching service to industries. The district on the whole is a high-grade residence section.

Increased train service due to the increase in traffic led to agitation for the elimination of grade crossings, which resulted in the passage of a Chicago ordinance in July, 1910, requiring the elevation of tracks on this line from Wilson Ave. to the city limits, about 4½ miles, where they connected with a similar but smaller track elevation project in Evanston. This work involves 38 street crossings and necessitates the construction of nine new passenger stations. Work on the project was started in 1915, but was stopped in 1917 on account of the war. It was resumed early in 1920 and will be completed next year. Track elevation at Evanston was carried out about ten years ago (see *Engineering News*, Feb. 10 and March 7, 1910, pp. 158 and 191).

With a 60-ft. right-of-way the elevation is built for four tracks, but at present only three tracks will be laid, the third (west) track being for freight service. When the fourth track is laid this will be used for freight, the third track then being given over to the elevated railway for express train service. A track spacing of 14 ft. c. to c. is employed, except at station platforms, where the spacing is 21.16 ft. for the two passenger tracks and 12.84 ft. between the passenger and freight tracks. At Howard Ave. two platforms will be used, making a different spacing necessary. Reverse curves of about 2 deg. will be used for the diversions at station platforms. The trolley wire system is used at present and will be used permanently for the freight track, but the passenger tracks will be equipped later with the third-rail system as used on the Chicago elevated railways.

Freight traffic was handled with steam locomotives by the C., M. & St. P. Ry. until Nov. 1, 1920, since which time the Chicago, North Shore & Milwaukee Electric Ry. has handled it with electric locomotives purchased for that purpose under an agreement entered into recently by the two companies. During the construction period freight trains were handled on the passenger tracks when necessary. As freight cars are wider than the cars of the elevated railway it was then necessary to install a four-rail gantlet in each passenger track at stations, so that the freight trains could be switched to the outer rails in order to clear the platforms.

Bridge and Trestle Design—Concrete structures are used throughout, except that at some long skew crossings steel plate-girder through spans have been used to meet the requirements of the Lincoln Park Commission. These steel spans have transverse floor beams supporting a concrete deck which is poured in place and encases the beams. In general, the bridges over streets have concrete abutments and supporting bents at the center of the street and at the curb lines. With the exception of the single-track trestle south of Wilson Ave. all the bridges now being built have slab decks poured in place at the bents and abutments, precast slabs having been used on some of the earlier structures. A typical bridge is that at Bryn Mawr Ave., Figs. 1 and 2, which has sidewalk spans of 11 ft. and 22 ft. respectively. For each track the deck is a single slab

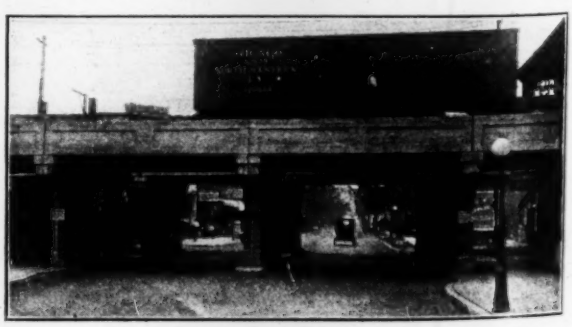


FIG. 2. BRYN MAWR AVE. BRIDGE ON CHICAGO-EVANSTON LINE; C., M. & ST. P. RY.

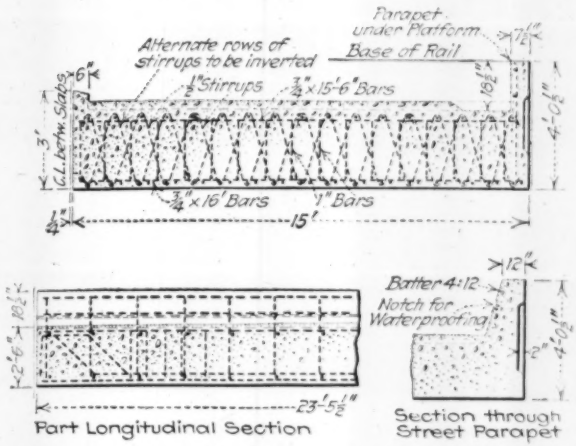


FIG. 3. CONCRETE DECK SLAB OF COLUMBIA AVE. BRIDGE

poured in place the parapet walls being formed monolithically with the outer slabs as shown. At stations, the tracks are carried by double track structures separated by a platform and the bridge construction is extended beyond the sidewalk to form the necessary subtrack space for station facilities.

Slab spans have fixed joints on the abutments and on alternate piers, being keyed to the supporting surfaces. Expansion joints are provided on the intermediate piers, the slabs having zinc plates cast into the bottom and resting on similar plates on the piers. These ½-in. transverse joints are packed with asbestos and asphalt filling. The decks which are built in place have only a longitudinal 1-in. construction joint, which is packed in the same way. Slabs for the Columbia Ave. bridge are shown in Fig. 3. Besides top and bottom bars in both directions there are continuous transverse stirrups of W-shape and longitudinal bent or shear bars.

Membrane waterproofing is applied to the top of the deck and is covered with 1½-in. layer of cement mortar reinforced with wire mesh, this covering being to protect the membrane from the stone ballast. On all slab work the concrete mix is 1:2:4, except that a 3-in. layer of 1:2 mortar is used for the bottom and top in order to secure a good covering for the steel and to form a dense surface.

A single-track concrete trestle 1,150 ft. long, with a grade of 0.3 per cent, connects the elevated line at Lawrence Ave. with the surface freight line mentioned later. The bents, spaced 20 ft. c. to c., are of rectangular form, consisting of two columns resting on a transverse footing and carrying a cap girder. Upon the girders will be precast slab spans for a ballasted track, as shown in Figs. 4 and 5. Each slab will be fixed at the north or upper end and free at the lower end. At present timber stringers are laid upon the concrete bents and intermediate pile bents.

Precast slab construction was adopted in this case as the structure carries only a single track and traffic could not be maintained over it if the concrete was poured in place. Experience on this railroad is said to indicate that there is no economy in the use of precast slabs. A slab casting and seasoning plant has been established on railway property along the line. The slabs are 11 x 22 ft., with a weight of about 43 tons, and will be handled and placed by derrick cars. A special feature in this slab deck is that provision is made for the future attachment of concrete brackets to carry plank walks, as shown. Pockets in the sides expose certain reinforcing bars to which the projecting bars of the bracket will be spliced, the pocket being then filled with concrete or grout.

Reinforced-concrete bents for the bridges consist of rectangular posts on heavy footings and supporting a cap girder. The bottom course of the footing is poured first, having key recesses in the top and having the vertical bars of the column embedded in it. The upper part of the footing, the columns and the cap girder form a monolithic structure. In the exposed portions of the bridges the columns are surmounted with a 2-in. coping, but for those portions which will be enclosed within the stations the copings were omitted. Abutments are of gravity section, similar to the retaining walls.

Stations—The stations are kept within the property lines and are located under the elevated tracks, the bridges being extended far enough beyond the street lines to provide the necessary space. Concrete stairways lead up through wells in the abutments to the platforms, as shown in Figs. 1 and 6, the typical arrangement being that shown in Fig. 1, with one island platform. Fig. 6 shows the special arrangement at Howard Ave., with two platforms, as noted above. The steps have a 7-in. rise and 10-in. tread, the latter being faced at the edge with anti-slipping material, and the remainder of the tread having granite screenings on the wearing surface. The platforms are 12 to 16 ft. wide, being limited by the narrow right-of-way. They will have wood flooring, which is considered the most suitable material where snow and ice have to be considered. The planks will be spiked to timber joists on steel I-beams carried by concrete piers. On each platform will be a canopy roof of butterfly type, supported by steel posts along the center of the platform, except that pairs of posts will be used at the stairways. The roof will be of ¾-in. ceiling boards with tin cover-

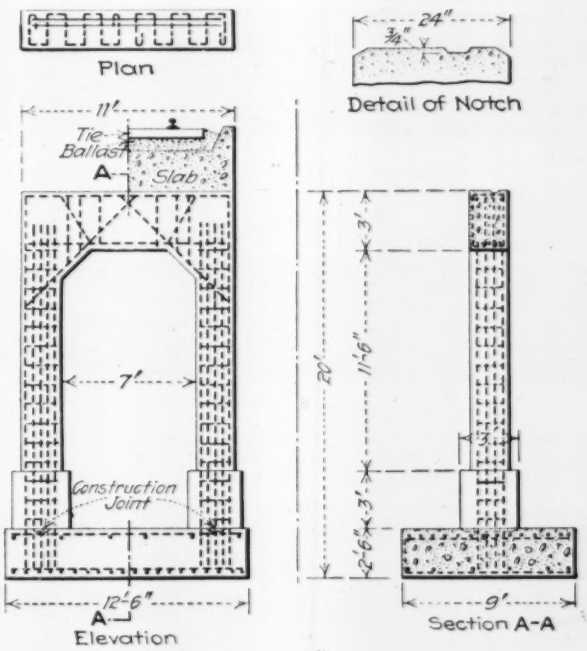


FIG. 4. TWO-POST SINGLE-TRACK CONCRETE TRESTLE

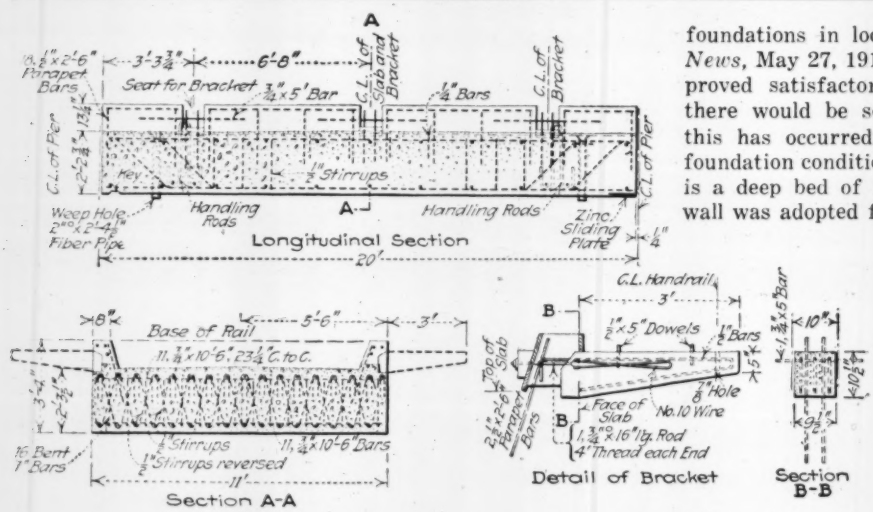


FIG. 5. DECK SLAB AND BRACKETS FOR TRESTLE

ing. This platform shelter construction is shown in Fig. 7.

Retaining Walls—Both cellular and gravity types of wall are used. In the cellular wall of reinforced concrete a relatively thin main wall is connected to a low back-wall or another wall by transverse tie walls embedded in the fill, as shown in Fig. 8. These walls are built in sections 30 ft. long, with the tie walls located approximately at the quarter points so as to equalize the moment in the cantilever portion and the center portion of the walls. The weight of the material upon the back wall and within the cells or compartments serves to anchor the structure in position, drainage of the enclosed sections of fill being provided by a line of 4-in. tile laid through holes in the tie walls, where necessary. In the higher cellular walls, the main or front wall has a small footing to reduce the load on the soil, but this was omitted in the walls of less height. The bottom of the footing is placed at least 3 ft. below the surface of the ground, on a deep stratum of firm sand.

The front wall is designed and reinforced as a slab held at the quarter points and subjected to earth pressure with a surcharge equivalent to Cooper's E-50 loading. For this loading the center line of the first track is assumed to be 6½ ft. from the right-of-way line (or face of wall), with the adjacent tracks spaced 13 ft. c. to c., the live load being assumed to follow a distribution slope of 1 on 2 from the ends of the ties. The maximum bearing under various conditions of loading shows about two tons per square foot beneath the front wall and about ½ ton beneath the back wall.

A similar cellular type of wall was designed a few years ago by the Chicago, Milwaukee & St. P. Ry. for its track elevation work at Milwaukee, Wis., the purpose in that case being to eliminate the necessity of deep and expensive pile foundations in loose material (see *Engineering News*, May 27, 1915, p. 1048). Those walls have proved satisfactory, but it was expected that there would be some settlement and in places this has occurred. On the Chicago work, the foundation conditions are quite different, as there is a deep bed of firm sand. There the cellular wall was adopted for use where the right-of-way runs through private property and no toe or footing could be permitted to extend beyond the property line. In order to provide for possible settlement the wall was built with its face 1 in. back from the property line. The height of front wall is from 16 to 22 ft. In the original design used at Milwaukee the back wall was built only between the tie walls of each section, the closed cells thus alternating with open spaces. In the Chicago work, however, this back wall is continuous, being built in 30-ft. lengths the same as the front wall.

A gravity type of retaining wall is used where the right-of-way parallels the boundary of a public thoroughfare, as the ordinance permits the foundation footings to extend a reasonable distance into the street. For some of the higher walls they extend about 5 ft. beyond the right-of-way and have a reinforced toe. These footings are below the grade line of the paving. This arrangement, shown also in Fig. 8, may be compared with that of the track elevation walls on the Rock Island Lines, in Chicago, where the toe of the footing is placed at the property line, the wall being set back but having a cantilever projection at the top which extends out to the property line (see *Engineering News-Record*, March 28, 1918, p. 622).

As shown by the typical section, the footing is built first, the wall being tied to it by a key groove and steel dowels. Reinforcing bars are used in the base of the footing. It was proposed to build some of the higher gravity walls in two horizontal sections, the first section being high enough to retain the slope of a three-track fill and the upper section being added when the fill was widened for the fourth track. This plan

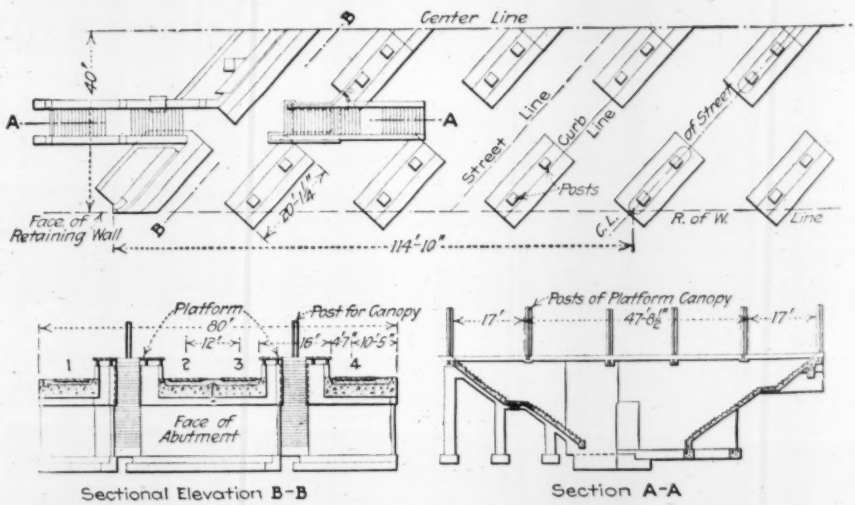


FIG. 6. SPECIAL PLATFORM ARRANGEMENT AT HOWARD AVE. STATION

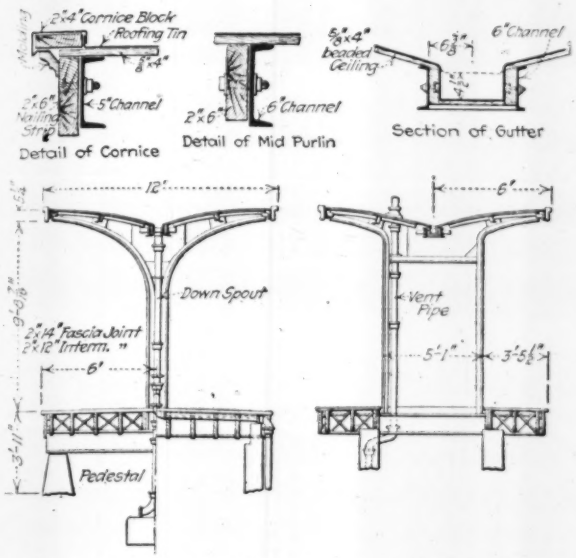


FIG. 7. PLATFORM SHELTER OF BUTTERFLY TYPE

was abandoned, however, and all walls are built to full height, the maximum being about 22 ft. These walls are built in sections 25 ft. long, poured alternately, with a key groove formed in each end of the sections first built. The maximum bearing load allowed on the soil is 2 tons per square foot. Gravity walls are of 1:3:6 concrete, with a 1:2½:5 mix for the footings. Cellular walls are of 1:2½:5 mix throughout.

CONSTRUCTION

Methods and Plant—Before work was stopped in 1917 considerable progress had been made on the east side of the line, the retaining wall and part of the bridges being completed, and fill deposited for two tracks. Thus the present concreting is not affected as much by the very heavy traffic which was a difficulty in the earlier stages of the work, as described in *Engineering Record* of July 15, 1916, p. 75. The filling also will be done from the new third track, which is on a trestle. In accordance with the policy of the Chicago, Milwaukee & St. P. Ry. the construction work on this elevation is being carried out by the forces of its own engineering department.

Three concreting trains are operated, each consisting of a mixer car with ½-yd. mixer, having four or five cars of stone (or gravel) and sand coupled at one end and a box car of cement in sacks at the other end. On two of the trains, the materials are delivered to the bins on the mixer car by wheelbarrows operated on runways laid over the cars. The other train is equipped with a 200-ft. cableway operating a 1½-yd. dragline bucket, the cables being carried by steel folding towers on the mixer car and on a car at the rear of the train, the latter car carrying a steam hoisting engine. This equipment, with the rear car, is shown in Fig. 9.

The cableway method of unloading and handling material was developed some years ago for other track elevation work on this road (see *Engineering Record* of Nov. 15, 1913, p. 544, and *Engineering News* of Nov. 20, 1913, p. 1018). Its labor-saving advantage is of special importance on the present work, in view of labor conditions, for a gang of 16 men with the concreting train which has the cableway equipment can do as much work as the 30 men required for the train on which material is handled by wheelbarrows. No difficulty is experienced in obtaining a sufficient supply of both skilled and common labor and the labor turnover is relatively small. Electric motors operate the mixers in both cases. Progress has been retarded by the usual difficulty in maintaining an adequate supply of materials.

With the train placed on the third track, all concrete is spouted directly into place. Where the drop from the mixer is considerable, as in placing foundations and the lower parts of the walls, flexible pipe chutes are used instead of troughs. All form work is of wood, that for the walls and abutments being built up largely in panels which can be handled as units and used several times. The forms are left in place about four days, and fill is not deposited against the walls for at least twenty days.

No surface finish is applied to exposed concrete surfaces after the removal of the forms, but in placing the concrete care is taken to work the cement to the side which will be exposed. For the parapet walls of bridges, the face of the form is plastered with 1:2 mortar as the concrete is deposited. Only the simplest decoration is attempted, including beveled corners, small fillets on the

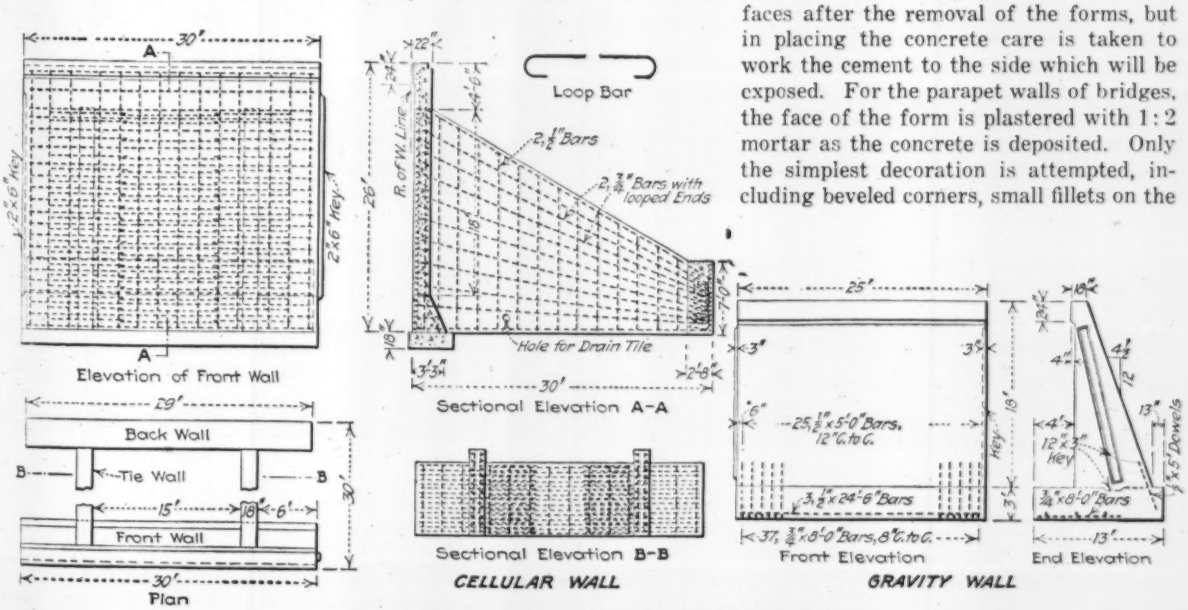


FIG. 8. CELLULAR AND GRAVITY RETAINING WALLS

columns of bents and large recessed panels on facia girders and parapet walls.

Cinders and refuse are used for filling, being deposited by gondola cars having side doors or drop floors. This filling is done from the trestle.

Construction work is in charge of T. H. Strate, engineer of track elevation. Structures were designed by C. N. Bainbridge, engineer of design. Both design and construction are under the general direction of W. W. K. Sparrow, assistant to the president. Charles F. Loweth is chief engineer of the Chicago, Milwaukee & St. P. Ry.

FIG. 9. CONCRETING TRAIN WITH CABLEWAY AND DRAGLINE BUCKET

Mississippi Levee Yardages

During the fiscal year ended June 30, 1920, a total of 12,537,564 cu.yd. of material were placed in the levees below Rock Island, on the Mississippi River. That amount brings the total amount of material in those levees, placed under the direction of the Corps of Engineers, U. S. Army, to 361,691,350 cu.yd. Considerable work remains to be done to bring these levees up to the standard fixed by the Corps. On June 30 the work contemplated under that standard was 76 per cent complete. These levees protect 27,116 sq.mi. of land.

In addition to the completion of this levee system it is believed by the Corps that a large amount of additional levee work must be provided for in the near future. Development in the State of Louisiana has reached a point where the Atchafalaya River either must be leveed or be divorced from the Mississippi River. The leveeing of that stream from the Mississippi to the Gulf would be a large undertaking. In the case of divorcement, the whole levee line on the Mississippi, from the Atchafalaya to the Gulf, would have to be materially reinforced. In this latter case, the engineering problem at the Passes, through which the Mississippi finds its way to the Gulf, would be made very much more difficult.

Preservative Treatment of Poles in Indiana

INCREASING use of preservative processes is shown by a study of pole conditions of the electric railway and other public utility services in Indiana recorded by R. V. Achatz in Circular 2 of the Engineering Department of Purdue University, at Lafayette, Ind. The conclusions presented may be summarized as follows:

A considerable percentage of the poles erected at the present time are receiving some kind of treatment, and the majority of companies using poles are either using such treatment or planning to use it on future work. Derivatives of coal tar are the most commonly used preservatives. Both the brush and open-tank methods of treatment are used, the latter either by simple dipping or by the hot and cold dipping process. Only the butts are treated, as a rule. Poles of the less durable woods treated by the pressure-tank process are more expensive than butt-treated cedar and chestnut poles, so that the former have not come into extensive use.

Under average conditions an increase in life of about two years will justify brush treatment, about 3½ years will justify the open-tank dipping treatment in hot creosote and about 7½ years will justify the hot and cold open-tank treatment. An increase in life greater than the above may be expected if these treatments are applied properly. For the lighter lines and for the smaller companies, or where first cost is an important consideration, the brush treatment offers some advantage. The open-tank dipping process gives greater uniformity and probably somewhat longer life than the brush treatment, which advantages are considered to overbalance the increased cost. The hot and cold bath open-tank treatment gives the greatest increase in life and is particularly suitable for heavy lines and permanent construction.

To increase the life of poles already in service, the most common method is to reinforce the weakened pole by driving a creosoted stub alongside it and binding the two together by wire. Another method is to excavate the earth from around the pole, clear away decayed wood and apply a brush treatment. Concrete reinforcement has been applied, but on account of the cost it can be recommended only for exceptional cases where the cost of replacement of the poles is very large.

Cost of Miami Flood-Protection Work

Total expenditures for flood protection to June 30, 1920, by the Miami Conservancy District have been $24,035,823 instead of $42,893,465 as stated in *Engineering News-Record*, Nov. 18, 1920, p. 979.

Use of Steel Reinforcement for Concrete Pavements

Behavior of Steel in Several Roads Leads to the Design of Two-Layer Reinforcement and Specification of Heavy Metal

By H. Eltinge Breed
Consulting Engineer, New York City

STEEL reinforcing in concrete pavement tends, in the writer's opinion, to lessen cracking in the pavement, to render more innocuous those cracks that occur, to prolong the life of the pavement by relieving the fatigue due to tensile stresses, and to justify its cost by increasing the service of the road, decreasing its maintenance, and sometimes offsetting the necessity for additional depth of concrete. These opinions, though formerly held, have been strengthened by a study recently made for the National Steel Fabric Co.

Last year more miles of concrete were laid in the United States than of any other type of durable pavement. The growth of the popularity of concrete as indicated by the laying of 941,659 sq.yd. in 1910 and 52,000,000 sq.yd. in 1919, has been little short of phenomenal. In response to a request for suggestions for an ideal section of the Lincoln Highway sent out by the Lincoln Highway Association, twenty-four of the forty replies which indicated a preference for a certain type of pavement specified concrete and nine of these suggested steel reinforcement. It is obvious that in many localities the concrete road is the cheapest of the durable types of pavement, that its cost of maintenance is low, and that people like it because it can be depended upon for service 365 days a year. However, we still have far to go in the development of the perfect pavement. It is the quest of that perfect type that lures the road-builder on to fresh adventures and discoveries. One may always expect the advent of a new type far superior to anything existing. Meanwhile, we must work to make the present good—better.

Cracks, Greatest Defect

The defect of the concrete pavement today is the cracks that appear upon its surface. If we can prevent these, we shall increase greatly the desirability of the concrete road. Although they have so far proven less serious than many other defects that mar our roads, cracks weaken the integrity of the pavement, and in the effort toward improvement we want to eliminate them. The cracks are of two kinds—transverse and longitudinal. They are due, as far as we know, to these causes: (1) Poor workmanship or poor materials, either of which is intolerable; (2) contraction due to variations in temperature and moisture content; (3) settlement of the subgrade; and (4) overloading and impact. Settlement is caused by frost action, by consolidation of the subgrade and by volume changes in the subgrade. The first of these causes we can and must prevent; the others we must offset. The most effective means of offsetting them that we have yet discovered is, I believe, the use of steel reinforcement.

The longitudinal crack is the more serious because, being along the axis of the road, it may catch the wheels of traffic like a track, and carry them along its length. The traffic, of course, chips off and wears down the edges, and a gash results, which requires maintenance. Transverse cracks tend to develop unevenness, one side becoming depressed. Traffic bumps over the ridge, and the resulting impact crumbles the edges and starts spalling. A. T. Goldbeck, engineer of tests, Bureau of Public Roads, reports some interesting experiments to determine the force of impact upon uneven surfaces. He says, in the proceedings of the American Concrete Institute for 1920:

> We have conducted a number of tests, using trucks of different size, in order to determine something of the amount of impact exerted on concrete roads, and it is rather surprising to find out just how much this impact can be. For instance, say you have a heavy truck, a three-ton army truck, which is very often a five-ton truck, and that truck has a total weight on one rear wheel of 7,500 lb. when the truck is loaded with five tons. When one rear wheel of that truck falls through a height of ¼ in. the impact on the road may be as high as 20,000 lb.; that is, the impact pressure produced may be as high as 20,000 lb., almost three times as much as the static load pressure. If the truck falls through a height of 3 in., which would, of course, mean an exceedingly bad road, you may get an impact pressure as high as 43,000 lb.

To build roads to withstand such impact as this last would be financially ruinous. What we can and must do is to build roads of such smoothness that there will be no intensification of the impact pressure.

It is perhaps well to suggest here that accidental cracking is not the only source of damage by impact. In the older concrete roads, metal-joint plates were used in the space between the slabs. Expansion and wear would gradually cause an unevenness at the joint. Then, while the hard metal remained intact, the less hard concrete on either side of it would suffer under the intensified punishment of traffic impact. In the new roads, metal-joint filler is no longer used. Thus one source of excessive wear is eliminated. The writer believes that wear due to accidental cracking may also be eliminated; first, by using every known precaution to prevent the cracking; second, where it does occur, by holding both sides level so as to prevent increased impact.

To hold the edges level and prevent the spreading of cracks where they appear is one function of steel reinforcement.

Road Stresses

Roads get stresses both compressive and tensile. Concrete will take compressive stresses, but it does not endure so well the tensile stresses generated by the impact of heavily-loaded motor vehicles. There has been much discussion about increasing the depth of concrete to withstand these so-called "shocks." The writer believes that impairment of a concrete pavement is due not so much to immediate shocks from above as to cumulative fatigue generated by intermittent tensile stresses. Another function of steel reinforcement is to take these stresses, lessen fatigue and thereby prolong the life of the pavement. The writer wishes that he might give definite, indisputable scientific data that would support these statements. He can not. He can only draw empirical conclusions from the studies and observations he has made.

Until 1918 he believed, with many other engineers, that the results gained from reinforcing did not justify its cost. He based this opinion upon the observation of concrete roads that were one to three years old. It has been offset by longer observation. For, while only a few cracks appear during the first year after a pavement is built, more develop during the second, and still more during the third, unless the pavement be reinforced.

Of the truth of this statement New York State Highway 5,314 is a good example. It was built in 1914 and a crack survey of it was made in April of 1915, 1916, and 1917. In two representative miles there were 1,479 linear feet of cracks in 1915; 3,210 in 1916, and 6,116 in 1917.

Need for Reinforcement Seen

The spectacle of this progressive cracking in this and in many other roads made the writer feel more keenly than he had prior to 1918 the need of a remedy. Further observation led him to believe that reinforcement would help certainly to an extent that would offset its cost.

Five hundred miles of concrete pavement were laid in New York State up to 1919. Seventy-five miles had reinforcement varying in weight from 22 to 25 lb. per 100 sq.ft. In some cases this weight of metal was doubled over bad soil conditions. The sections reinforced are in better condition today, under the same condition of soil, aggregates, etc., than the plain sections are. It is noticeable that with an increased amount of metal the cracks are fewer and the pavement surface is in better condition.

With this study in mind the writer, during the past two years, has been designing his pavements with reinforcement of 40 lb. per 100 sq.ft., decreasing in many cases the thickness of the pavement as the amount of metal has been increased, and thereby offsetting costs. For instance, a povement that would have been designed 9 in. thick without reinforcement on a 10 to 8 section, was designed instead 8 in. thick with a steel reinforcement of 40 lb. per 100 sq.ft. At $5 a square yard a 9-in. pavement is worth 55c. per inch of depth. Forty pounds of metal per 100 sq.ft. can be placed for about 25c. per square yard, figuring 6c. a pound f.o.b. shop, for the reinforcement. This would show a net saving of approximately $3,168 for a mile of pavement 18 ft. wide, exclusive of the saving in cost of an inch in excavation, and not considering the lengthened service of the pavement, or its decreased maintenance due to the reinforcement.

C. M. Upham, chief engineer, Delaware State Highway Department, said, speaking before the American Road Builders' Association in 1916 of the use of reinforcement in Delaware roads:

> With one exception, as the percentage of reinforcement increased the transverse cracks became fewer. The increased cost due to reinforcement was 9c. per square yard. If the reinforcement were not used, and the money were put into concrete, it would add but ½ in. to the thickness of the road.

Two-Layer Reinforcement

The writer's opinion is put into practice on a city pavement he is now constructing at Bennington, Vt., where he is using 40 lb. of metal per 100 sq.ft. on the narrow sections of the street on either side of the car track under medium to light traffic. The concrete is 6 in. deep and the slabs 8 to 9 ft. wide.

On this same contract in the main street of the city *he is using 75 lb. of material in two layers—40 lb. in the lower layer and 35 lb. to the top,* with a width of slab from 14 to 18 ft. The pavement is most of the way on a coarse gravel and sand foundation. In another small city where there is a considerable amount of ground water the writer has designed on a clay soil a 6- to 9-in. cinder base with drains on which there is to be placed a 7-in. concrete pavement with 45 lb. of metal per 100 sq.ft. along a 40-ft. street with a car track in the center.

Recent inspections indicate that, other things being equal, the greater the amount of metal used the better will be the pavement. For those who want the evidence, a detailed statement of a few of the roads visited is given in appendices at the end of this article.

The writer has tried to enlarge his experience vicariously. The fact that reinforcing is still in the experimental stage makes it rather difficult to get definite opinions concerning it. Some questionnaires have been sent out with varyingly valuable results.

The committee on reinforcement for the second national conference of concrete roal builders prior to 1916 sent out letters to 844 engineers known to have laid concrete road or pavements. Of the 319 replies received 40 per cent furnished information about 300 miles of reinforced concrete roads and pavements. Partly on the basis of this information the recommendations of the committee were made.

They advocated the use of reinforcement on the following scale:

Width of road —ft.	Weight of of metal per 100 sq.ft.— lb.	Sectional area Transverse	Sectional area Longitudinal	Ratio
16	40	.09	.03	3 tol
30	50	.12	.03	5 tol
40	60	.15	.03	5 tol

The committee report was not adopted, but a resolution was adopted the sense of which was that the reinforcing be left to the discretion of the individual engineer. The conclusion of the convention is well expressed however in the following recommended practice formulated by the committee on resolutions and adopted by the convention: "In general the use of reinforcement is advisable." This was one of the twelve fundamental principles adopted by this committee.

The committee on cencrete roads and pavements of the American Concrete Institute, of which the writer was chairman, selected engineers who, it was generally recognized, had had extensive experience in concrete road and pavement construction, and sent to them questionnaires in January, 1920. Sixty-six were sent out and twenty-three were returned. The main idea of this questionnaire was to get such information as would help the committee in rewriting its specifications and recommended practice. Of the twenty-three engineers who replied, thirteen used and believed in steel reinforcement. It is interesting to note that of those thirteen, eleven stated a preference for the wire type of reinforcement as it gives a better distribution of steel and increases the bond strength on account of greater superficial area.

A few practical suggestions for future use of reinforcing steel may not be amiss, in view of the large amount of it that is being specified. In New York and Pennsylvania alone there were put under contract in 1919 9,000,000 sq.yd. of reinforced concrete pavement.

1—One of the great dangers in using reinforcing steel is that road builders, given an additional factor of safety, may be tempted to use a leaner mix, poorer materials and poorer workmanship. Such construction would only defeat its own purpose. Reinforcing steel is in no sense an apology for poor materials or poor construction. It merely would be added waste to use it in poor work.

2—On account of the fact that transverse cracks are not as dangerous as longitudinal cracks, and as the latter are the ones to be eliminated if possible on account of the destructive effect of traffic running along them, it would seem wise to take a metal that has a ratio of from one, lengthwise, to from three and one-half to five, across the pavement. Many of the standard designs now have about this ratio and the writer believes it gives the best results. In city work, however, where transverse cracks are more detrimental, the ratio should be one, lengthwise, to from one to two and one-half, crosswise, depending on the length of the slab.

3—With the increased use of steel, slabs can be lengthened without the danger of transverse cracks.

Other Considerations—So far in all our road work we have been trying to build for the needs of the day. Always tomorrow has overtaken us unprepared. During the last 15 years every year has seen an increase in loading and in density of traffic. However, legislative restriction has now limited the total load to about 30,000 lb., and the design of most of the pavements being built today has that maximum loading in mind. We are gradually getting our highway problems into fewer variable terms, but we do not yet know how large a part steel will play in road building. Some have claimed that it will do for highways what it has done for structural building. This is improbable. Buildings and bridges are designed with certain definite, unyielding supports, with no supporting medium below certain parts of the slab; while in highway design all parts of the slab are supported with varying uniformity by a base estimated to give a certain amount of stability. It is this varying uniformity of base that precludes absolute accuracy unless one wants to design extravagantly for maximum weakness.

If a highway slab were reinforced heavily enough to take its loadings in the same manner as the slab design of the building, the cost would be excessive. This is not necessary. In building work failure is often disastrous, but on a highway it may be cheaper to allow one slab to fail and be rebuilt adequately to the poorer foundation, than uniformly to reinforce the whole roadway in accordance with the worst condition found. The future of highway development depends upon the economic use of present funds. To use steel rationally it will be necessary, even on the same highway, to build varying thicknesses of pavement with varying amounts of steel to meet varying conditions of foundation and traffic.

Conclusions

The analogy between the use of steel reinforcing for structural work and highways will not hold, but the writer believes that steel will be a factor in helping us build better roads. With the proper use of the right amount of reinforcing steel, pavements can be built to withstand the increased traffic that will be put upon them.

This article deals specifically with the concrete type of pavement but several other durable types of pavement which have for their base a concrete foundation can be effectually treated with reinforcing steel so as to put them in competition with the concrete pavement. Cracks are many times as destructive under sheet asphalt or mixed asphaltic concrete pavements to the pavement surface as cracks are to the concrete.

It is upon the observations given above, which are typical of many others that he has made, that the writer bases his statement about the two-fold function of steel reinforcing: It preserves the integrity of the pavement, and prolongs its life.

Appendix A

Long Island—Road 743 in Suffolk County, Long Island, N. Y., between Babylon and Bayshore was an old bituminous macadam pavement 16 ft. wide and 6 in. thick. In 1916 the section of this road from Sta. 0 to 92 + 40 was resurfaced with a 1: 1½: 3 gravel concrete 20 ft. wide, 6½ in. thick in the center and 4½ in. thick at the outside edge. As the center line of the new work was on the center line of the old work it left an overhang of 2 ft. of concrete on each side that had as a support only gravelly-sand soil, while the center 16 ft. had the advantage of the old macadam as its foundation. In order that these 2-ft. wings should not break off, mesh reinforcement was specified that should weigh not less than 0.25 lb. per sq.ft. This metal was to be 2 ft. wide and placed midway at the depth of the slab so that a foot of the metal would be over the old macadam foundation and a foot over the ordinary subgrade. At the western end of the pavement slabs are intact and no cracking appears over the point of change in the foundation material. In the latter half of this work, however, thirty slabs with a total length of 900 ft. have cracked at their edges close to the change in foundation condition. When we looked unusually hard for reinforcement in this latter part, it appeared as though it might not have been put in. The western end of the road, which still shows no cracks, was, for a quarter of a mile, reinforced. Then the contractor ran out of reinforcing material and the work was carried on without it in order not to check progress. Cracking resulted.

Compressive Strength

The action of the section in which the reinforcement was used is particularly good considering the fact that the average strength of the concrete cube composed of mortar concrete taken from the mixer and tested at 28 days shows an average strength for the 1: 1½: 3 mix of only 2,308 lb. This is unusually low, as most New York State road work runs well over 3,000 lb. per square inch, compressive strength. This low strength was due to the fact that local gravel was used which contained a large percentage of material from ¼ in. to ½ in. in size with only a small percentage of the material over 1 in.

A traffic census on this road taken from 8 A.M. to 8 P.M. on Aug. 21 and 22, 1920, shows a count on the first of these days of 2,384 vehicles, of which 180 were light-delivery trucks and 78 were heavy-delivery trucks. On Aug. 22 the count was 3,091 vehicles, of which 56 were light-delivery trucks and 23 heavy-delivery trucks. The traffic during 1917 and 1918 was much heavier because quantities of material for Camp Upton (as well as supplies for two near-by aviation fields) were hauled over this road.

Appendix B

New Jersey—New Jersey affords other instances. In 1914 a clay fill was made upon a marsh about 5 ft. above mean tide. Two sections of road were built over it which have had to carry extremely heavy traffic. The first section, on the Fort Lee Turnpike, built in 1917, was 3,500 ft. long. This pavement was 20 ft. wide and from 8 in. to 10½ in. in thickness of a 1: 2: 3 mix of concrete, using Cow Bay sand and trap rock as coarse aggregate. Forty-five pounds of metal per 100 sq.ft. were used as reinforcement and placed 2 in. below the top. The slab length was gener-

ally 20 ft. The grades ranged from level to 2 per cent. There is only one crack in the entire length and that is over a culvert which held its position while the fill at both sides settled.

Fort Lee Turnpike Section

The other section, built in 1919 on the Fort Lee Turnpike, is 1,000 ft. long, 24 ft. wide and from 7½ to 10½ in. thick, of a 1:2:3 mix, in which Cow Bay sand and trap rock were used as coarse aggregate. Forty-five pounds of metal per 100 sq.ft. were used as reinforcement, and placed 2 in. below the top. The slabs are 36 ft. long. The grades range from level to 1 per cent and there are no cracks of any description in the pavement.

By way of comparison let us take a section of the Bergen Turnpike only two miles away. It is not reinforced. Under similar conditions as to soil, marsh, etc., this road was also laid in 1919 with even greater care than was taken with the other two sections. It is 3,450 ft. long, 18½ ft. wide, uniformly 9 in. thick, of a 1:2:3 mix in which Cow Bay sand and trap rock were used as coarse aggregate. The length of slab is 36 ft. The grades here are level. Yet there are in this pavement 32 longitudinal cracks, 3 transverse cracks, and 3 diagonal cracks. Two cracks are spalled to a width of 3 in. The road has begun a yearly maintenance charge; the other two are practically intact. The conclusion is obvious.

Another piece of pavement which the writer inspected was the Kearney-New Jersey-County Road which runs from the Trexler Lumber Co. to the Plank Road. It was built in 1919. This is just off the Lincoln Highway. The length of the pavement is approximately 3,300 ft. The pavement is 24 ft. wide, and 10-12½-10 in thick. The mix was 1:2:3 using a ¾-in. limestone aggregate. One hundred and fifty pounds of metal per 100 sq.ft. were used as reinforcing, 75 lb. being approximately 2.5 in. above the grade, and the top layer from 5 to 6 in. above this. The slab lengths are from 36 to 54 ft., the average being about 40 ft. The road is constructed over filled ground on a cinder fill. There are no cracks in the entire length except at a point where the railroad track was placed diagonally across the pavement. Here the concrete shows a crack at a narrow section of the slab, which came when the pavement was broken through for the railroad. The traffic using this section is the heaviest kind of motor traffic that serves the industrial plants surrounding it.

Section in Ridgefield

Grand Avenue in Ridgefield, N. J., takes the heavy motor truck traffic from Jersey City northward through Nyack. It is 3,923 ft. long, 22 ft. wide, 7-10-7 in. thick, and of a 1:2:3 mix in which Cow Bay sand and trap rock were used as aggregate. Forty-five pounds of metal per 100 sq.ft. were used as reinforcement, which was placed 2 in. below the surface. The average slab length was 36 ft., some slabs being as long as 100 ft. This road was built in 1918 and is on a side hill. The soil is clay over trap rock. Drainage is provided for by tile upon the hill side. The grades range from level to 2 per cent. There is only one crack in the whole length, it being in one of the 100-ft. slabs which has a transverse crack near the middle.

The writer has seen many similar pavements without reinforcing which were badly cracked. It appears, therefore, that in this pavement the reinforcement has saved the cost of constant maintenance.

Another interesting piece of pavement was that on Totowa Avenue, Paterson, N. J. This is 600 ft. long, from 26 to 28 ft. wide, and 6-8-6 in. thick, of a 1:2:3 mix. Local sand and trap rock were used as coarse aggregate. Thirty-one pounds of metal per 100 sq.ft. were used as reinforcement, which was placed 2 in. below the surface. Slab lengths are from 15 to 30 ft. This pavement was laid in 1916. There are no cracks. The surface condition shows that the sand used was dirty, or of a poorer grade than that generally found in Jersey work, because it had worn down around the aggregate. This pavement is laid on a clay soil and on an 11 per cent grade and carries moderate city traffic. Considering its age and condition the metal reinforcement is probably the cause of no cracking.

Appendix C

William Penn Highway—Another pavement inspected was the William Penn Highway from Easton to Allentown, Pa. The pavement is seven miles long, 16 ft. wide, and 6-8-6 in. thick, of a 1:2:3 mix. The amount of metal used was approximately 0.25 lb. per sq.ft., placed 2½ in. from the surface. The slab length was 39½ ft. The soil is clay over limestone with a possible presence of ground-water pockets. Underdrainage was placed along the side to care for this condition. Although there are numerous cracks in the pavement the greatest width observed in any one was ¼ in., and the metal held the breaks to such an extent that the riding surface of the pavement was perfectly smooth and even.

In a number of cases a crack having started at the edges or in the center of the slab did not continue across to the outside edge of the pavement as it generally does when no steel is used. The amount of metal used seemed beneficial because it kept the broken sections of slab at a uniform level and saved the destructive effect of impact generated by unevenness. It has also held broken sections closely together and saved maintenance and upkeep costs. The condition of the pavement is much better than other pavements without reinforcement, both built under similar conditions as to thickness, mix, soil, age, etc.

Appendix D

Wayne County, Mich.—Grand River Road, Wayne County, Mich., built in 1910, 16 ft. wide and 6½ in. thick, of two-course construction, was widened to 20 ft. and resurfaced in 1916 with 3 in. of 1:1½:2½ concrete of washed sand and trap rock ¼ in. to 1 in. in size and reinforced with wire mesh weighing 28 lb. per 100 sq.ft. The writer was enthusiastic over the success of the experiment in widening and resurfacing when he visited the road in 1917. Another survey made last month showed that but very few cracks had developed in the three years, and those were negligible, showing neither spalling nor wear. This road has heavy traffic. A 14-hr. traffic count in 1920, taken as an average from seven consecutive days, showed 2,558 vehicles, of which 486 were motor trucks.

Truck Registration in the United States

According to reports of secretaries of state and estimates made by statisticians of the D. F. Goodrich Rubber Co., there were 953,093 motor trucks in operation in the United States at the end of 1919, says a recent issue of the official magazine of the Motor Truck Association of America. The 1919 figure represents an increase of 37 per cent over the estimate of 700,000 trucks in operation at the end of 1918. Ne exact figures are possible inasmuch as only 18 states of the 48 keep separate registration lists for motor trucks.

The following is the estimate of the Goodrich Co. by states: Alabama, 10,249; Arizona, 3,200; Arkansas, 5,600; California, 58,700; Colorado, 13,500; Connecticut, 19,799; Delaware, 2,100; Florida, 3,239; Georgia, 9,300; Idaho, 5,600; Illinois, 65,000; Indina, 36,000; Iowa, 42,500; Kansas, 27,800; Kentucky, 9,105; Louisiana, 7,100; Maine, 5,792; Maryland, 10,160; Massachusetts, 42,000; Michigan, 36,863; Minnesota, 34,300; Mississippi, 6,350; Missouri, 25,000; Montana, 1,000; Nebraska, 27,300; Nevada, 700; New Hampshire, 3,902; New Jersey, 20,000; New Mexico, 2,810; New York, 94,716; North Carolina, 9,150; North Dakota, 1,314; Ohio, 64,500; Oklahoma, 20,100; Oregon, 11,300; Pennsylvania, 64,200; Rhode Island, 7,000; South Carolina, 9,600; South Dakota, 14,205; Tennessee, 12,000; Texas, 42,250; Utah, 5,300; Vermont, 2,402; Virginia, 11,800; Washington, 23,600; West Virginia, 6,700; Wisconsin, 10,887; Wyoming, 2,900.

Functions of Rapid Transit Lines in Cities

Capabilities of Each Transportation Agency Outlined—Effect of Geographical Distribution on Transportation Conditions

By Henry M. Brinckerhoff
Of Parsons, Klapp, Brinckerhoff & Douglas, Consulting Engineers, New York City

(Reprinted from the *Electric Railway Journal*)

THE average visitor and most residents if asked how the people habitually travel about New York City will answer, "The vast majority on the subway and elevated lines, a smaller proporton on surface cars and a few on buses." This popular conception of the situation is largely due to constant newspaper discussion of subway congestion and the vivid impression made by long crowded trains following one another in quick succession at subway and elevated stations during rush hours.

Studying the statistics over a period of years, we find, on the contrary, that the surface car has borne the great burden of transporting the bulk of the citizens of our large American cities and that only in the past few years has even New York carried one-half of the total daily passengers on its rapid transit systems. This division of the growing New York travel during the past forty years is interesting, particularly as related to the population of the city. Other cities in the United States are now approximating the size that New York was thirty or forty years ago and, growing rapidly, they have ahead of them the probability of the same or similar traction problems.

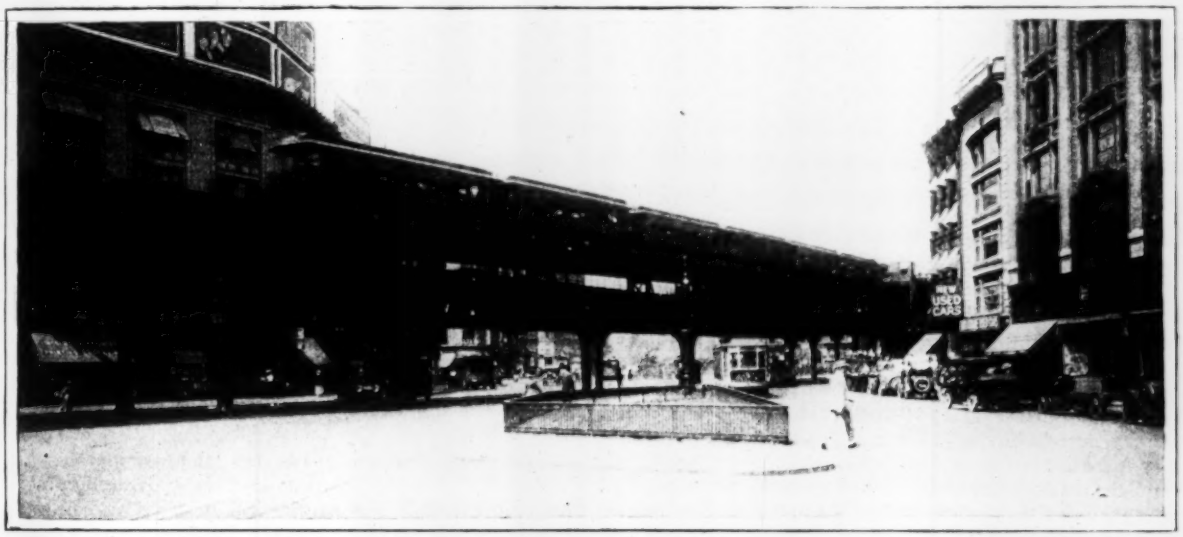
In 1880 we find that 79 per cent of the passengers on the transportation lines of what we now call Greater New York were carried by surface cars, the population then served comprising about 2,000,000 people.

In 1900, twenty years later, the ratio was still 70 per cent surface car passengers to 30 per cent carried on rapid transit lines, while the population served had grown to about 3,500,000.

Almost another score of years brings us to 1919, when, after the expenditure during this latter period of more than $550,000,000 for subways, third tracking and extending elevated lines and additional rapid transit equipment, we find 43 per cent of the passengers still paying their nickels for rides on surface cars. This condition is not peculiar to New York, as we shall see by a study of the history of transportation in other large cities.

In Chicago in 1906, with a population of about 2,000,000, 75 per cent of the revenue passengers were carried by the surface cars, and in 1919, with the population increased to about 2,800,000, 75 per cent of the people are still patrons of surface car lines.

In Philadelphia the Market St. elevated-subway line, with its free transfers between rapid transit trains and surface cars, makes a good showing in passengers carried per car-mile, but as part of the entire city lines it carries not more than 10 per cent of the passengers served by the whole system.



WHERE ELEVATED, SUBWAY AND SURFACE LINES CROSS, 66TH STREET AND BROADWAY, NEW YORK

In Boston the surface-subway-elevated lines are so interconnected and the movement of passengers is so complicated by transfer privileges that a division is difficult. However, the proportion of the passengers actually handled here by surface cars is still large.

Turning to England, where the conditions of city development have been quite different, we see in London an even wider variety in the division of the passengers among the different classes of carriers, but still the rapid transit not in the majority Here the motor bus (successor to the time-honored horsedrawn vehicle) assumes imposing proportions. The ratios of passengers carried may be taken as about 27 per cent on tram or surface cars, 33 per cent on motor buses and 40 per cent on rapid transit trains.

Greater London, with an area of almost 700 sq. miles and a population of about 7,250,000, carries one-third of its traveling public about the city in motor buses operated in crowded, heavily trafficked streets.

Greater New York at the other extreme, with a population of almost 6,000,000, distributed over about 327 sq. miles, or one-half London's area, carries 55 per cent of its city riders on rapid transit lines and not more than 2 per cent on buses.

Chicago, with a population of almost 3,000,000 and an area of about 200 sq. miles, carries 75 per cent of its travelers by surface cars, while Detroit and Cleveland, now at the 1,000,000 mark in popluation, are entirely dependent upon surface car transportation.

With such contradictory general facts before us we must apparently go to a more detailed analysis of conditions to draw any valuable lesson from past experience in the large cities of the world. In doing this the first question that presents itself is whether the study of existing systems will be of fundamental value in guiding us to a solution of modern transportation needs, in a large city in accord with present-day thought.

Here appears to be the crux of the question. The existing transportation facilities in large cities are the result of private initiative, building for years along lines where greatest pecuniary profits were to be reaped. Only recently has this guiding motive been supplanted by effective public control, and this has often been directed to meet certain specific needs rather than a general solving of the whole problem.

We are today at a point where a broader view must be taken of city transportation planning in the interest of the traveling public's needs and convenience. The public must pay for the service directly or indirectly, but it must get what it pays for. The idea of the most profitable type or location of lines is, therefore, no longer absolutely controlling and we are face to face with the problem of supplying transportation to our large cities as a recognized public necessity like water supply, paving and sewerage. The fact that an adequate circulatory system for a city's red-blooded working units is as necessary for civic growth and health as is a sound arterial system for the human body is becoming more generally recognized. In the solving of this problem city and company must co-operate to overcome successfully the physical, financial and legal obstacles that will be met.

The time has come when a hearing can be obtained for an analysis and discussion of the complex elements of transportation from the viewpoint of the needs of the city as a whole. The purpose of this article is to point out the uses of subway and elevated lines with such a broad view of the situation in mind, but in doing so reference to other forms of city transit are necessary to maintain a balance and completeness in the picture.

Analysis of City Travel

The real need for extensive transportation facilities in a large growing American city arises principally from the desirability, or often the necessity, for the individual workers to live beyond walking distance from their place of employment. By the term "worker" is meant any wage earner or person having regular employment or business and consequently regular habits of travel. The hauling of these people to and from their work constitutes the great bulk of the rush-hour traffic, hence a careful study of their riding habits is a valuable index to their transportation needs.

A canvass of the principal factories of the city of Cleveland showed that 52 per cent of their employees lived beyond the walking distance of 1 mile from their shops. Detroit showed 71.8 per cent, and a canvass in Chicago, locating the homes of 350,082 wage earners from all classes of shops, factories, retail stores and office buildings, showed 75.6 per cent living beyond 1 mile and therefore dependent upon transportation to earn their living.

An exhaustive detail study of the transportation habits of the people of a large city involves a great amount of work and the co-operation of many interests and has not often been undertaken. The most recent complete collection of data of this kind in contained in the report of the Chicago Traction and Subway Commission of 1916 and the figures there developed will here be used as illustrating the basis of the division of riders between surface and rapid transit lines and the causes influencing their choice of routes.

An analysis of the Chicago residential canvass, which covered all employment centers within the city area, showed a wide scattering of nearly all classes of workers over the many residential districts of the city. Thus it was possible to prove the almost universal need for transportation and also the great diversity of routes and combinations of car lines used by a people in a single residence district in reaching employment centers, and, vice versa, the widely separated localities from which the factories drew their workers.

The American wage-earning family averages five persons, father, mother and three children, of whom three are usually workers. Unlike families in England or on the Continent, the children in America do not as a matter of course learn the trade of the parents, but each follows his own bent, with the result that they travel from their home center in many different directions seeking employment. It is the aggregation of many thousands of such families which creates the diversity in the transportation demands of our large cities.

The Chicago residential canvass when compared with simultaneous traffic count on surface and rapid transit lines showed that the origin and destination of daily trips of 50 per cent of the individuals composing the rush-hour crowds had been determined. As an indication of the probable proportion of these rush-hour travelers who require rapid transit, a charting by ½-mile districts showed that 44.3 per cent made trips to and from work of more than 3 miles and 31.6 per cent of more than 4 miles. The rapid transit lines of the city carried 22 per cent of the total traffic against 78 per cent on the surface cars on the week-days checked, while for the calendar year the ratio was 25 per cent to 75 per cent.

Adopting the generally accepted idea that more than 3 miles constitutes a legitimate rapid transit ride, the inference is that the elevated lines were inadequate or some other elements influenced the result beyond the mere question of distance. It was found that the principal element was "time," and its closely related factor "direct routing." By means of transfers from line to line the surface system offered routes, particularly cross-town, which saved time over less direct although higher speed rapid transit lines.

To determine the time factor the Chicago Loop Dis-

trict was selected and 115,085 workers of all classes employed in this crowded city center were located as to residence, the data being shown on a chart on which each black square indicated by its size the relative number of workers residing in that 1-mile area who were employed in the Loop District. These, for our purpose, can be classified as indicated in Table 1.

TABLE I—OCCUPATIONAL DISTRIBUTION OF WORKERS IN CHICAGO LOOP DISTRICT

Occupation		Transportation Used		Per Cent
In office buildings	32,113	Elevated Railroads	64,847	56
Department and Retail stores	32,755	Surface cars	43,344	38
Clothing manufacturers	10,045	Steam suburban	3,921	3.4
Banks and general offices	26,622	Walkers	2,973	2.6
Printers and engravers	3,304	Total	115,085	100
Miscellaneous	4,378			
Wholesale dry goods	5,868			
Total	115,085			

Analyzed by distances from home to work, the division was as shown in Table 2.

as to have become almost a vice of the New Yorker.

On one surface car line in Detroit a traffic count showed that 85 per cent of the passengers either transferred to or from other lines, only 15 per cent of those carried starting and ending their journey on the line itself. At the City Hall in Detroit the Woodward Ave. line received or delivered 57,817 transfer passengers daily who utilized ninety-two different combinations of routes at this point. A similar condition exists at the Public Square in Cleveland, where 79,451 transfers were observed in twenty-four hours, more than 100 different combinations of lines being used.

The Chicago investigation showed clearly that the transfer privilege at more than 545 intersections of surface lines was a great factor in determining the routing of passengers; from 10,000 to even 25,000 transfers occurred daily at single intersections. Many groups of large numbers each were found who took the first leg of their journey on a nearby surface line and transferred to another surface car, running parallel to a rapid transit line, for a 4, 5 or 6-mile ride.

TABLE II—CLASSIFICATION CHICAGO LOOP WORKERS BY DISTANCE TRAVELED

	Total	0-1 Miles, Per Cent	1-2 Miles, Per Cent	2-3 Miles, Per Cent	3-4 Miles, Per Cent	4-5 Miles, Per Cent	5-6 Miles, Per Cent	6-7 Miles, Per Cent	7-8 Miles, Per Cent	8-11 Miles, Per Cent	11-14 Miles, Per Cent	Over 14 Miles, Per Cent
	115,085	3.7	11.0	11.4	15.6	15.7	12.9	10.5	7.6	6.2	1.7	3.7
Accumulative total, per cent		3.7	14.7	26.1	41.7	57.4	70.3	80.8	88.4	94.6	96.3	100

Deducting the walkers (2.6 per cent) in the last tabulation, it is seen that 39.1 per cent rode 4 miles or less, which closely matches the surface car percentage shown above.

The analysis of this office and retail district canvass gave a good idea of the division of riding of the classes most easily attracted to rapid transit by reasons of ability to live in restricted residence districts and working short hours. A similar analysis of the immediately adjacent factory district west of the river including 31,670 workers, showed 16.7 per cent walkers, while 53.6 per cent lived within the 3-mile limit and 69.8 per cent within 4 miles of their shops, 83.3 per cent in this factory district being dependent on transportation.

The difference in these two sections lay almost entirely in the character of the people employed. The average for the whole city was: Walkers (under 1 mile), 24.4 per cent; those living within 3 miles from work, 55.7 per cent; within 4 miles, 68.4 per cent; the per cent of workers daily using transportation being 75.6 per cent. When rapid transit routes are laid out, therefore, the character of the population to be served is an important element to be considered.

A special inquiry into time-saving covering 6,000 of the above workers in the Loop District supplied the data for the curve, pg. 1238. The individuals inquired of for this purpose were selected because they were as conveniently located for reaching either surface or rapid transit lines. They were also distributed over a wide area and at varying distances up to 16 miles from the Loop. This chart therefore gives a good idea of how people of this class divide on the question of time saving in a city like Chicago, other conditions being substanially equal.

When the original Interborough subway was laid out many loud criticisms were made of the local and express transfer stations, voicing the idea that on short trips people would not trouble to change cars. Today exchanging from local to express trains and back again for a saving of even a couple of minutes is so common

Careful study of complete 24-hour checks of passengers on the surface and elevated lines of Chicago clearly demonstrated that these two large competitive systems serving a population of more than 2,500,000 distributed over 200 miles of territory, due to their lack of co-ordination, did not function in such a way as to give the best service of which they were capable.

When the problem of enlarging the Chicago city transportation system as a whole was attacked by the commission it became still more apparent that additions to the existing systems on a basis of unified operation not only gave more capacity for a given expenditure but provided a greater variety of convenient routes to riders and would also prove to be more economical to operate.

Transportation is a necessary function of a city's life as a whole. It is not confined to districts, classes of people or occupations. It is as democratic and cosmopolitan as the population of the city itself. Such being true, a division into separate lines serving only portions of the city is purely artificial, and the result of a system of development of these facilities by individuals largely influenced by hope of profit and with capital limited by the assurance of a return on their investment has been piecemeal construction.

When taken up from the viewpoint of the interests of the entire city's traveling population the proper arrangement to accomplish a complete solution is a single unified system the elements of which will each give the maximum of service at the least cost, both capital and operating. It is not within the scope of this article to discuss the many legal, financial and other obstacles to accomplish a general unification of all transit facilities. However, the function of subway and elevated lines is so dependent upon their relation to the other modes of transporting city passengers that whether they should properly be considered as competitive independent systems or should function as part of a harmonious whole seems to warrant the foregoing discussions.

In order to consider the realtive value of these four kinds of service in a complete unified city system it is simpler to compare ratios of cost or performance freed from local conditions. Present cost of construction, operating expenses, etc., are so abnormal and are changing so frequently even on the same system that direct comparisons are misleading without a multitude of explanations. For our purpose the following general statistics are typical of good American practice on average large city systems:

Maximum Passenger-Carrying Capacity per Hour.—One way, one track: Bus, 1; surface, 1.7; elevated, 6; subway, 7. This means that large two-car units on surface lines will carry a little less than twice the bus line under similar street conditions. The elevated with eight-car trains will supply six times and a subway with ten-car trains seven times the bus line passenger capacity. This is on the basis of allowing for standees, large cars and maximum peak load conditions.

Speed in Miles per Hour.—Average city conditions (Fifth Avenue Coach Company, 8½ miles per hour): Bus, 1; surface, 1; elevated, 2; subway, 2. The surface cars and buses are about equal in average speed and the elevated and subway twice as fast.

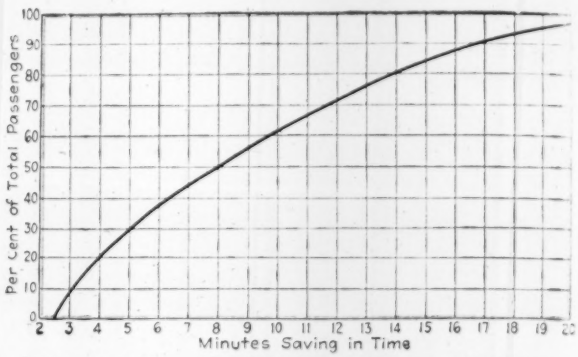
From these two items it is plain that where large crowds are to be handled and the haul is long the subway and elevated are immensely superior, having seven times the capacity of a bus line and twice the speed. As the presence of large passenger crowds means usually street congestion, these types have the additional advantage therfore of not occupying street space.

Cost of Operation per Car-Mile.—(Fixed charges excluded.) Subway, 1; elevated, 1.2; surface, 1.8; bus, 2. Here the economy of train operation with infrequent stops and on an easily maintained unobstructed right of way places the subway at the top of the list.

Operating Cost per Passenger Carried, 1919 figures—(Fixed charges excluded.) Subway, 1; elevated, 1.2; surface, 1.4; bus, 2.6. This proportion is taken from averages of the actual 1919 figures of American systems so far as they can be brought into direct comparison. In these figures there is of course reflected the length of haul, in which regard the rapid transit lines have the worst of the bargain as they carry their passengers probably twice as far as the surface and three or four times as far as the bus lines.

Capital per Mile of Line.—Bus, 1; surface, 2; elevated, 12; subway, 36. Here the bus line makes the best showing, with the surface line at double the cost and the subway three times that of the elevated.

On the face of these figures the subway costs thirty-six times as much as the bus lines and has only seven times the passenger capacity. If, however, the two are compared by requiring the buses to move the subway load, seven lines of buses would be required and a total street width of 230 ft., or four times the width of Fifth Ave. at 42nd. St., If this widening were charged against the bus system the cost would be fabulous. Similarly, if a subway were built to carry a load of 7,000 passengers per hour, one train every ten minutes would carry them and the fare would have to be ridiculously high to cover the enormous fixed charges. The fact is that such direct comparisons are futile and go to prove that each of these systems has a limited field of its own. Each type should be used for the service to which it is peculiarly adapted and if properly



USE OF RAPID TRANSIT FOR SAVING TIME WHEN SURFACE LINES ALSO ARE AVAILABLE

incorporated as part of a single system will reach its maximum effectiveness and efficiency.

In view of these comparisons, it is quite apparent that subways should be confined to the main arteries of the city system and so far as possible to the densely trafficked districts. As the elevated form of structure supplies the same passenger capacity and speed as the subway the logical plan in the interests of economy is to come to the surface with the subway and extend the service by elevated wherever the building and property damage is not too great. Much talk was indulged in a few years ago advocating the taking down of the elevated railroads in New York, but today with the express service on the third tracks no one could conceive of abolishing this system and replacing it with subways at three times the cost.

When people speak of subways they visualize the New York ten-car train system in rush hours and when they mention elevated lines they think of the old Ninth Avenue, New York, or the Chicago Union Loop Lines with their unsightly appearance and noise.

It is a pity that this latter conception cannot be supplemented with more up-to-date possibilities. In a city like New York, with its multiplicity of traction companies, its narrow and infrequent north and south streets and its unprecedented volume of rush-hour traffic, four-track subways paralleling one another may be justified, but in other cities whose rapid transit history is still to be written quite another procedure is not only possible but necessary.

Subways as such have no inherent virtue. They are, as we have seen, three tims as costly to build as elevated lines and eighten times as costly as surface lines. Why then should we not take the surface line, which usually exists and which the subway will parallel, and leaving it on the surface of the street as a local service transfer vertically to the subway express service below.

Consolidation of Various Systems Desirable

By utilizing the surface lines as local and feeder lines and transferring long-haul passengers down to subway or up to elevated express trains a vast saving can be shown over the building of a competing rapid transit system. This latter, if competitive, must draw its patrons from the limited territory immediately adjacent to its own lines. This lack of transfer surface feeders is one of the causes of the beehive type of apartment housing in New York.

In a radial city like Chicago or Detroit the building of rapid transit lines to all outlying sections is financially impossible. The intermediate areas between trunk

lines will be well served by surface lines with transfers to these rapid transit lines.

Such a single system, it can be shown, will give greater facilities than two competing systems and at a far lower cost per capita.

The consolidation of city systems has been frowned upon by some people because it creates a monopoly, but with proper public control this is just the very element necessary for success in giving all classes of people the vast multiplicity of services called for by the activities of a big city.

The dismemberment of some of the consolidated New York Traction groups is an object lesson pointing the way in the opposite direction. Subways and elevated lines are necessary parts of the traction system of a great city, but they should have combined with them surface and bus lines as feeders, all functioning as part of a single system.

Military vs. Civil Control of Construction in War Time

An Army officer's objections to the conclusions of the civilian Board of Review, appointed by the Assistant Secretary of War to investigate the work of the Construction Division.

By Major C. L. Hall
Corps of Engineers, U. S. Army, Washington, D. C.

YOUR issue of Sept. 23, p. 590, contains an abstract of the report of the Board of Review appointed by the Assistant Secretary of War to consider the work done by the Construction Division during the late war. The writer was in France during the entire war and is, therefore, unable to comment upon the parts of the report dealing with the specific performances of the Construction Division, and with the recommendations of the board in regard to improvements in the form of contracts. The report contains, however, certain statements of opinion in regard to some phases of Government construction, which are, to say the least, arguable.

The statement is made that under peace conditions, and, to a large extent under war conditions also, nearly all construction and the engineering incident thereto is of a civil character. It is true that the construction of barracks and quarters in time of peace does not differ essentially from the ordinary building operations of civil life, but the total amount of such army construction is small, it involves no peculiar difficulty and its execution, so far as the writer knows, has been satisfactory. It is certainly true that if differences between the constructing personnel and the organizations which have to use the buildings when constructed were of an extra-departmental rather than an intra-departmental character, and hence required the ruling of the President on each specific case, the net waste in friction would far out-balance any theoretical advantages due to greater specialized experience of civil engineers.

The statement made by the board, that construction and the engineering incident thereto in time of war are of a civil character, is entirely contrary to fact. While its instructions limited this board to a consideration of the work done in the United States, and while it, therefore, apparently gave no thought and certainly made no mention of the work done in France, it is a fact that this latter work, which exceeded the amount done in this country, involved construction and engineering all of a military character. In France, no line was drawn between the quasi-civil and purely military construction, and an attempt to do so would merely have resulted in disorganization and confusion.

The whole reasoning and all the recommendations of this Board of Review are evidently based upon the assumption that in all future wars the actual fighting will be far beyond the continental limits of the United States and the conditions which will prevail will be similar to those which existed during the World War. No greater fallacy could ever be perpetrated and no reasoning based upon such a fallacy is worthy of a moment's consideration. All of our peacetime organization must be planned so that it will, so far as is humanly possible, meet any conditions which may arise. As nearly as can be now foreseen, the probability that our next war will be fought on this continent is at least as great as that the actual fighting will be done beyond our own continental boundaries. In any war on this continent the theater of operations will much more nearly resemble the situation in France, the gradation from semi-permanent work at the extreme rear to dug-outs at the front will be very gradual. Again, the conditions under which construction in war-time is done are essentially different from those in time of peace and it is very doubtful whether the experience gained in civil life can be as advantageous to the government as that gained by army officers who are accustomed to thinking of, and dealing with, war-time matters.

This board states that time does not permit a thorough and varied training in practical commercial work in the education of army engineer officers, and reasons that, therefore, they will be outclassed by civilian engineers in most construction work. This is entirely gratuitous, pure inference, and, so far as the writer knows, is unsupported by facts. The army engineer can point to many structures erected by him which it is believed will compare favorably with any similar work done by civilian engineers.

The board also recommends that, so far as practicable, the directing and executive engineers on all government construction work should be drawn from civil life. This is further evidence that it has again limited its study to a single special case rather than to the broader view which would embrace other contingencies. Most certainly all construction work in the theater of operations must be placed under the Chief Army Engineer. It cannot be done otherwise. Materials of construction are scarce and the allocation of them between the front line and the rear elements of the theater of operations is one of the principal duties of the military authorities and a duty which men without military training are utterly unqualified to perform.

The Board of Review argues that if the organization handling construction work were directed by the War Department it would be disrupted in war by the transfer of its personnel to military work. It may be pointed out once more that all of this construction work during war is essentially military work. Certain work of a civil nature, such as the river and harbor work of the Corps of Engineers, was not disrupted by the late war. Transfer of the personnel of many of the civil bureaus into the military service is to be expected in war-time as a matter of course.

The Board of Review then proceeds to advance a recommendation which is practically an argument for

the formation of a Department of Public Works. This is entirely by the way and has no place in a discussion of the advisability of having essentially military construction work done by a civilian bureau. The organization which the board recommends for a construction bureau is practically identical with that of the Office of the Chief of Engineers, U. S. Army, at the present time. Further comment seems superfluous.

The board argues delightfully that the War Department is an organization normally inert, which cannot expand to the full proportions necessary for meeting all army needs in a war emergency. According to proper military thought the War Department is organized to assure the efficient expansion of a small peace army into a large army in war. It must be organized on principles which permit of such expansion. If a War Department composed of trained military minds is not better fitted to control and supervise our expansion to a war basis than civilians having no military point of view, then we had better disband the army entirely.

The creation by expansion of a construction bureau is an utterly insignificant task compared with the creation by expansion of a field army. As a matter of fact, of all the departments of the government the War Department is by far the best fitted to handle emergency work in war-time, and, moreover, is the only one (except the Navy Department) whose personnel is habitually trained to study the subject and which is in readiness to bring about the proper, well balanced and immensely larger war-time organization.

The Board of Review states with some gusto that the results in war construction were accomplished largely by freeing experienced constructors from control by army officers. Once more it is dealing with a special case in the United States. Its conclusions certainly do not apply to the work done in France. There, one of the principal faults found with the untrained civilians was that when anyone of them was given anything resembling a free hand, he proceeded with his own work and sought to obtain all the material it required, with an utter disregard for the necessities of other departments or even of the front line. Furthermore, the work was largely successful in proportion to the degree of comprehension of military conditions by its directing heads. It is again emphasized that construction during any war on this continent will distinctly resemble the work done by the American Expeditionary Force in France.

It is believed to be very unfortunate that the writers of this report seem to have known nothing of the work done in France. Had they possessed this knowledge they would have known, first, that construction within the theater of operations is essentially a military problem, regardless of the precise nature of the work; second, that the theater of operations on land extends from the most remote base ports clear up to the front-line trenches; third, that however successful the Construction Division may have been in the late war, there is absolutely no evidence, judging from the work of the Engineers in France, that the work would not have been as well done if carried on under the direction of the Chief of Engineers, U. S. Army.

Attention is invited to the fact that these conclusions, upon military matters of the utmost importance, were arrived at without consultation with the General Staff or the Chief of Engineers; and without discussion (so far as known) with any military men except those whose activities were being investigated. Under such circumstances the recommendations of the board should have no weight either with the engineering profession or the American people.

Wide Streets and Roads Recommended By British Engineer

IN DISCUSSING the planning and development of traffic facilities for towns and outlying districts, J. A. Brodie made several recommendations in his inaugural address as president of the British Institution of Civil Engineers, which are reprinted below from a recent issue of the *Surveyor*:

Many of our roads are too narrow to permit of motor vehicles passing bulky loads which are so prominent a feature in many country roads. When the more permanent road materials are being laid, it is also a great advantage to be able to construct one portion of the carriage-way while the remainder is used for the passing of ordinary traffic. It is probable, therefore, that no width of carriage-way less than 30 ft. will meet the requirements where any considerable amount of traffic is to be expected, and carriage-ways 36 ft. in width, with ample margins and separate foot paths, should in many cases be provided.

The time has probably arrived when the erection of any house or building immediately abutting the side of any main road should be prohibited by law. The question of how far buildings should be kept back is important, but, bearing in mind dust and noise, and the danger to children and domestic animals from passing traffic, the adoption of a universal building line for new erections not less than 60 ft. from the center line of the main road is to be strongly recommended. The land lying between the house and the road need not, in most cases, be added to the road, but when the house is built to the new line, such land might be made use of as gardens; alternatively, the land could be utilized for ordinary agricultural purposes until required by traffic.

When dealing with roads outside built-up areas some consideration should be given to the necessity for the construction of new trunk roads in this country, and there can, I think, be little doubt that a limited number of such roads should be laid out wherever the amount of traffic is likely to warrant their construction.

The surfaces should be capable of taking all the various types of land traffic at present in use, and it would appear that one double-track railway for goods, and also a double track for an electric passenger and goods service should be provided. At least a double track for heavy motor wagons in each direction would be required on such a route, as is shown by the large amount of traffic of this description which is at present making use of the main roads at certain times of the day, and a double track in each direction should be provided for light vehicles. The foregoing provisions would necessitate a width of at least 150 ft., and, as ample width for future requirements should be provided, it is probable that 180 ft. in width between fences would be looked upon as reasonable. The ordinary cost might, under existing conditions, amount to about $200,000 per mile.

With regard to surfaces for roads throughout the country, cases will no doubt arise where the amount of heavy traffic is so great that paved surfaces will have to be adopted The lighter surfaces provided by the different types of asphalt, tar-macadam, and pitch-macadam, appear to be more generally favored for ordinary traffic in this country.

A few lengths of road have been laid in England of the American type of concrete road surface, in which the wear is being taken by the concrete direct. The feeling among English engineers appears to be in favor of surfacing concrete roads with a slight coat of tar, pitch, or asphalt mixture, in the nature of a carpet.

Constructive Criticism of New York's Port Problem

Discussion of Control, Operation, Extensions and Improvements Before Local Section of Am. Soc. C. E Brings Out Recommendations for Bettering Conditions Generally Conceded Bad

CONSTRUCTIVE criticism of New York's port problem, based on broad and diversified aspects, was brought out at the meeting of the New York Section of the American Society of Civil Engineers, Dec. 15, which considered the subject, "The Port of New York." It was almost unanimously conceded that present conditions are bad and there was general agreement for the need of creating a port authority. The meeting was opened by Colonel W. J. Wilgus, president of the section, who broadly outlined the major subjects requiring consideration and the principal paper was presented by B. F. Cresson, Jr., chief engineer, New York-New Jersey Port and Harbor Development Commission. Mr. Cresson's paper was followed with discussion by ten engineers and port authorities and the reading of four communications, during which a debate took place between Murray Hulburt, commissioner of docks, New York City, and Julius Henry Cohen, counsel of the joint harbor commission, on the effect of the proposed port treaty between the two states.

An abstract of Mr. Cresson's paper and the discussion follows:

An Analysis of New York's Port Problem

By B. F. CRESSON, JR.
Chief Engineer, New York-New Jersey Port and Harbor Development Commission

PLANS FOR belt line railroads, terminal markets, the West Side Manhattan railroad problem, interconnection of rail lines over or under harbor waters have all been proposed, but little has been accomplished in respect to a general plan for the reorganization of the port of New York because of lack of administrative control and of exact knowledge of the problem. The solution should begin in the administration of the district. The problem is not local, since half the foreign commerce of the United States passes through the port. Neither New York nor New Jersey can work out the best plan by itself, and unless worked out jointly, the Federal government may step in, which would not bring a satisfactory solution due to jealousies of other ports.

The business of the port is so great and the problem so involved and so complex that no reorganization plan can be effected without knowledge of all of the factors, which include studies of the geography of the port, and adjacent populations; administration, political and legal considerations; previous history of individual endeavor; ocean shipping; port machinery; warehousing; trucking; layout of the port and railroad connections; lighterage; marketing of foodstuffs; barge canal terminals; ferries, and the study and planning of the port as a whole.

When the date for this discussion was fixed it was thought that the report of the joint commission would be before the public, but rather than postpone this paper it was thought wise at this time to lay before the Society a general statement of the fundamentals of the New York port problem, which is unique since the territory lies within two states with a total population of some 8,000,000 people—5,900,000 in New York, and 2,100,000 in New Jersey. The government of the waterfront of New York City is under the dock commissioner, the Board of Estimate and Apportionment, and the Commissioners of the Sinking Fund of the city. In New Jersey port jurisdiction is divided between perhaps forty municipalities. For lack of a central port authority, development has been along lines of individual endeavor, including the development of ocean-shipping terminals, railroad connections, lighterage, trucking and warehousing, although some terminal companies have operated jointly, demonstrating the possibilities of economy thus possible.

LAYOUT OF THE PORT—RAILROADS AND SHIPPING

In the main the principal railroads reach the port on the New Jersey side and rates cover delivery in New York City within the lighterage limits, the rails of only one freight carrier entering Manhattan by direct connection. But the principal shipping facilities are on Manhattan. New Jersey's frontage is mostly devoted to railroad and industrial occupation, while New York's is largely commercial. The new Staten Island piers and the projected Cunard terminal at Weehawken will be a great addition to present shipping facilities.

Development industrially of Queens and the Bronx has lagged for lack of convenient connection with the principal railroads since these reach the port from the west, with yards located immediately back of the New Jersey waterfront for the break-up and transfer to car floats or lighters. The cost and delays of such operations have been regarded as very great, but at the present time are unknown for lack of uniformity in accounting systems and methods by the various railroads. To arrive at a figure representing average cost per car and per ton for New York terminal service is an exceedingly laborious operation due to the complexity of the problem.

It has been proposed to bring cars from the West across the North River by bridge or tunnel to join the New York Central. Such a project must be thoroughly analyzed with respect to cost, return, amortization and public advantages. In addition, the problem of better railroad connections with other boroughs than Manhattan must be considered. New Jersey now has too much railroad waterfront occupation, necessary by reason of individual operation and accommodation for lighterage and car floating, and relief would be of the greatest value in Jersey communities to permit the development of the water front for shipping terminals. The advantages of the bridge plan must be weighed as an economic problem and other plans must be analyzed, such as the halting of cars in New Jersey and the movement of freight to and from Manhattan by motor truck, by special equipment or by a joint water service.

For a study of the shipping problem the volume and character of the business must be determined from the Custom House, the War Department, the Department of Commerce, etc. It is possible to assume that New York's shipping may be bettered by zoning. The character of the principal commodities handled must be determined in developing freight-handling machinery and the design of piers and warehouses in general. Lighterage must be considered due to the large volume of business so handled. It must be determined whether piers are used too intensively as warehouses, rather than transit sheds. The general method of handling cargo freight is burtoning, and there is little doubt that additional machinery within the piers is needed as well as cranes.

MARKETING AND TRUCKING

Bound up tightly with the railroad problem is the marketing situation and the handling of highly perishable commodities for the 5,900,000 New York population, requiring a plan fairly considering the interests of producer and shipper with quickest delivery and minimum expense to consumer. The study involves determination of volume and character of commodities, method of shipments, where they originate and the process by which they finally reach the consumer. It has been the general opinion that great sums are lost through delays to trucks caused by congestion and inability to deliver and discharge freight promptly, and a careful analysis of the entire situation is necessary. With

the development of the motor truck it is possible to relieve the railroads of a considerable amount of short-haul business. New York's trucking problem, not only within Manhattan, but also in outlying boroughs and in New Jersey communities must be studied. With such facts indicating the extent of possible relief or congestion in railroad and steamship terminals it will be possible to lay out a more uniform system of truck operation that will save money and time to producers, carriers and the public.

In New York there is a deficiency of warehousing and storage accommodations, since the problem has not been considered a part of the transportation problem but rather as a separate business, so that waterfront terminals are limited in operation by lack of readily accessible storage space, resulting in slow turn-around of ships and holding of railroad cars for purposes of storage. The problem is a very important one, and by proper solution deliveries can be speeded up and demurrage of ships and cars reduced. A thorough canvass of location, capacities, facilities, etc., must be made to provide additional and more accessible warehousing.

There is the possibility of greater efficiency in the use of lighterage equipment by consolidation and unification of operation in the movement annually of about 60,000,000 tons by this method. Other subjects which must be studied are barge canal terminals; canals and waterways; private terminals; stevedoring operations; tariffs, charges and rates; ferries; handling of fuel, grain and building materials; channels and dredging; banking and commercial operations, and electric power supply. But these do not complete the list of subjects.

Planning the Port as a Whole

Not until suit had been brought before the Interstate Commerce Commission, which if granted would involve a differential railroad rate within the port itself, did commercial interests awake to the momentous situation and as a result the Governors and Legislatures of the two states created and financed a commission to study the port problem as a whole without respect to political boundary lines. After a preliminary study a report was made to the legislatures declaring that two years and an expenditure of $400,000 would be required to complete the work. The commissioners realized that no plan involving changes in operating conditions and large expenditures of money can be put into effect unless based upon economic proof of financial and operating soundness. It has been sought by analysis to determine the actual facts of the case.

The proposed treaty between the two states already recommended by the joint commission will adequately protect the municipalities in the investments and facilities already made and created, and there is to be no pledging of public credits for development but merely the creation of a central body with sufficient authority and power to encourage private or public initiative to construct modern terminals as part of an organic whole.

Discussion of the Problem

IN OPENING the meeting Colonel Wilgus expressed the hope that those to take part in the discussion would not hesitate to advance views that would be helpful in later discussing the solution that the joint commission is expected to propose in the forthcoming report and that the major points for consideration were: (1) channels and slips; (2) the effect of the railroad and seaboard rate structure on more efficient freight interchange; (3) pier dimensions, general design and equipment; (4) handling machinery; (5) liaison between piers and shore facilities; (6) co-ordination and unified management of the railroads of the port in conjunction with a belt line, and, (7) more effective means of local distribution and collection of freight. Colonel Wilgus emphasized the experience of the war as demonstrating so clearly the wisdom of proper port planning.

The secretary read two communications from Pacific Coast port engineers—G. F. Nicholson, chief engineer, Port of Seattle, and G. B. Hegardt, engineer, Commission of Public Docks, Portland. Mr. Nicholson telegraphed that the ideal administration for the Port of New York would be a commission of seven members including representatives of shipping and railroad interests and terminal engineers, appointed for life by the Governors of the two states or by the Federal government. Publicly owned terminals should be publicly operated. A 40-ft. channel depth is sufficient for efficient operation, but engineers should design pier and dock facilities to permit a 50-ft. depth at a future date. Piers should be wide enough to accommodate two shipside tracks on either side and two storage sheds at least 120 ft. wide on either side with four depressed tracks in the center. When supporting long warehouses and grain elevators are needed, they should be just to the rear of the transit shed in the quay development, and in the pier development the latter should be widened to 550 ft. and warehouses placed between the sheds. All terminal trackage on the harbor side of the classification yards should be under control and operation of a harbor commission.

Another Pacific Coast Opinion

Mr. Hegardt, in his telegram, stated that the following points for a satisfactory solution of New York's problem should be considered: (1) Satisfactory channels; (2) convenient connection to railroads and belt line; (3) terminal site of dimensions and trackage adequate to permit of most rapid loading and discharge; (4) piers and slips constructed with quay feature retained, and vessels berthing along only one side of pier, whether single or double, and piers to be filled where practicable and to have flush tracks at front and depressed tracks in rear; (6) one-story transit shed big enough to permit discharge without change of berth (from experience in Portland 180-ft. width has been found most practicable); (7) slip-side platform of pier 32 to 34 ft. wide for double track and gantry crane service and rear platform 12 to 14 ft.; (8) where filled piers are used, slips should be 250 to 300 ft. wide; (9) standard mechanical equipment including cargo masts, locomotive cranes in the absence of pier cranes, electric trucks, tractors, piling and stacking machines, one- to two-ton electric cranes and conveyors, for the transit shed; (10) provision for the construction of modern pier cranes; (11) sufficient space for adequate trucking and rail trackage, as well as site for switching track; (12) turning back vessels with the greatest dispatch is the objective that should be accomplished. This cannot be attained with narrow piers and inadequate trackage.

A communication from Capt. F. T. Chambers, chief engineer, Port Facilities Commission, United States Shipping Board, stated that co-ordination and unified control of the port as proposed in the treaty between the two states should be effected and that regulation of the railroads points to harbor regulation. If New York refuses to enter such an agreement New Jersey has the means to develop ocean and rail terminals. A belt railroad system should be begun without delay and the Jamaica Bay propect should be pushed. Additional storage facilities as a part of the transportation system should be established to prevent the use of cars for warehousing as at present; the Interstate Commerce Commission is likely to issue an order against the existing practice. If the public were sufficiently enlightened there would be separate terminal charges for New York, which would thus lose business.

Opinions from Philadelphia and Montreal

George S. Webster, chief engineer, Department of Public Works, Philadelphia, emphasized the necessity of wide piers and stated that he was "convinced that in a port where railways lead to the waterfront wide piers should be constructed." In Philadelphia there is no waiting of trucks at the wide piers as at the narrow piers. Particular attention should be paid proper rail and truck connection to piers to tie in waterways with other means of transportation. Mr. Webster was followed by John Meigs, consulting engineer and former director, Department of Wharves, Docks and Ferries of Philadelphia, who said that present facilities at New York are on the wrong side of the Hudson River for efficient distribution to the hinterland. New York is the most expensive port in the country and dray service is particularly costly. The present rate structure for free

delivery in New York is at the center of the problem and there is a possibility of an Interstate Commerce Commission order that will so regulate rates as to force business to New Jersey. The question must be approached with caution.

F. W. Cowie, chief engineer, Harbor Commissioners of Montreal, said that New York had two distinct problems on account of physical separation by the Hudson River, each being of essentially different character. The city should operate the New York facilities, and the nation, the New Jersey facilities. Mr. Cowie emphasized the advantages of centralized location, citing the successful development of the ports of Liverpool, Montreal, and Hamburg.

A. W. Robinson, mechanical engineer, Montreal, said that the whole question was one of prime importance to railroads and ship owners and that the problem was to build and manitain such ports and port facilities as would result in the quickest dispatch of full cargoes to and from the largest ships that are economical to operate.

E. P. Goodrich, consulting engineer, New York City, said that it hardly seemed necessary to design the entire port for very large ships since these constituted such a small portion of the whole. He defended the Port of New York with the statement that Montreal and Philadelphia shippers had been known to ship through New York, with transfer to rail and truck. It is sometimes better to pay ship demurrage than interest on expensive pier equipment and narrow piers are better for lighterage. Open tracks along pier fronts are sometimes wasteful in requiring longer trucking distance from ships to sheds. Store-door delivery in New York is possible and would be advantageous. "Think what the advantage would be," said Mr. Goodrich, "if cars could be unloaded on the Jersey Meadows into motor trucks for Manhattan."

A Railroad Viewpoint

"The port that grew up and then 'blew' up during the war" was the characterization of the present New York situation as expressed by J. J. Mantell, terminal manager, New York district, during the Federal control, and now general manager, Eastern region, Erie R.R. "If the wastefulness that exists is not checked," said Mr. Mantell, "it will bring ruin to the port." It now costs more to move freight from Hackensack into New York City than it does to haul it from Cleveland or Pittsburgh. New York terminal cost to the railroads on the west side of the Hudson River, for which they are allowed as much as 80c. per ton on some classes of freight, is estimated at $2.50 per ton not including major overhead charges. Narrow slips hamper railroad lighterage. New York should have a "rail-head port" and the principal requirements for relief are: (1) a belt line railroad and multiple storage in New Jersey; (2) development of store-door delivery; (3) double-deck bridge across the Hudson River; (4) the taking over and electrification of existing steam suburban passenger lines. "The vehicular tunnel," said Mr. Mantell, "will be overloaded a year after it is built."

A statement was read from F. W. Williams, state engineer, New York, outlining the aims for developing traffic on the New York State Barge Canal. Mr. Williams would be inclined to favor Federal control of the port, except that the necessary, immediate and vital interest would be lacking. New York State is vitally interested in the port problem because of state land holdings, and the State Barge Canal will benefit New York City more than any other locality. He emphasized the necessity of proper handling machinery at the Port of New York for canal barges. Ship, rail, barge, and truck transportation can be co-ordinated by proper machinery.

The work of the engineering staff of the joint commission was praised by J. Spencer Smith, member of the Commission and chairman of the Board of Commerce and Navigation of New Jersey. The port problem does not center on shipping but is a railroad and distribution problem. "The railroad problem must first be solved," said Mr. Smith, "but it cannot be solved by co-operation alone, since unity of action is needed." New Jersey by the action of its legislature has acted and agreed to the treaty and asks no favors, and public opinion should be so awakened as to bring about like action by New York. The rate case was brought by New Jersey only to bring the matter to a head so that New York would take action.

Murray Hulbert, commissioner of docks, New York City, said that he wished to refute the statements of some of the previous speakers as it was evident that they had given consideration only to "the theoretical side." He said that long-term leases of piers is the factor that has prevented modernization since, according to the City Charter, plans are prepared to suit the tenants and piers must be leased in advance before construction could be undertaken. He said that it was necessary "to do more than discuss the problem from a theoretical standpoint."

The Proposed Port Treaty—Pro and Con

Mr. Hulbert took exception to statements that have been made in the press in regard to the new Staten Island piers and said that engineering plans *had* been prepared. He said that ultimately there would be more space for ocean shipping on Staten Island than on Manhattan and that the Staten Island piers now under construction would determine by their operation the best future design. Commissioner Hulbert said that the Jamaica Bay development, the South Shore Flushing Bay terminal, and the terminal on the east shore of the Bronx should go forward and that the removal of the New York Central tracks on the west side of Manhattan would knit together the boroughs of the city.

Commissioner Hulbert, who is a member of the joint commission, said that the commission's proposed treaty would be fatal because it would split authority, because the votes of five out of six members of the commission would be necessary to carry. Exception to this statement was taken by Julius H. Cohen, counsel of the joint commission, who said that the proposed treaty would accomplish exactly the things Commissioner Hulbert wished to accomplish and that it was a treaty of co-operation only as the first step. "Some source of power" is needed. After a sharp debate with the commissioner on legal points at issue, involving the debt limit of the city of New York and bonds secured by city property, Mr. Cohen said that the problem must be treated as a whole, but that it would not be possible to get such unified authority as at New Orleans or Montreal. He said that the fact that engineers are taking up such problems broadly is a "splendid augury that they are coming to play their part in great public services."

Smoke Ordinance for Salt Lake City

Elimination of the smoke nuisance at Salt Lake City, Utah, which is made a particularly difficult problem by local atmospheric conditions, is the purpose of an ordinance passed by the City Commission Nov. 1. This ordinance had been prepared in connection with a report submitted by Osborn Monnett, consulting engineer, after an extended study of the situation. It provides that the City Commission shall appoint a chief smoke inspector and may appoint four deputy inspectors, an advisory committee of seven members and a board of appeals of three members. The annual salaries are not to exceed $3,000 for the chief inspector, $2,400 for the two engineer deputies, and $1,800 for the two inspectors who are not engineers. The members of the advisory committee and the board of appeals will serve two-year terms without pay.

Plans and specifications for construction and alteration of boiler plants and furnaces must be approved by the smoke inspector, fees of $2 and $5 being required for residences and business places respectively. Emission of "dense black smoke" is limited to one minute, or not more than six minutes in any one hour, and this latter only when the furnace is being cleaned or charged. The penalty is a fine of $10 to $299 for each offense.

Status of Government Inland-Waterways Experiment

General Hines Gives Particulars Regarding Mississippi-Warrior River and New York Barge Canal Routes

THE status of the U. S. Government's experiment in inland-waterway transportation, since the war, was reviewed in one of the papers at the transportation session during the annual meeting of the American Society of Mechanical Engineers, in New York, Dec. 9. The presentation was made by Frank T. Hines, late brigadier-general, U. S. A., now chief of transportation of the government's inland and coastwise waterway service.

General Hines, after outlining the wartime development, familiar to the readers of *Engineering News-Record* through repeated references in its pages, pointed out that the operation of these lines by the government had been a hard, uphill fight. In no instance until the present summer had they shown actual operating profits in any one month. Construction of the new equipment, particularly power units, had been delayed far beyond the original delivery dates, which had in turn prevented the movement of traffic with the regularity, dispatch and economy which had been hoped for.

On the service between New Orleans and St. Louis the average monthly deficits up to October, 1920, have been $50,000. On the Warrior line these losses have been slightly less, yet averaging over $30,000 each month. On the New York Barge Canal, however, with the delivery of the new types of power units during the present season, actual profits have for the first time been earned. For the whole year, however, taking into consideration the five months during which these boats must be tied up, the total earnings will be little more than the expenses.

The carrying of continued losses can be justified, in General Hines' opinion, only because of the benefits which may be derived by commercial interests of the country from the establishment of an efficient, co-ordinated network of transportation lines on inland waterways, capable of transporting coarser commodities at cheaper rates than can existing rail facilities. Whether this can be done is still doubtful, but many authorities believe that it is possible. Before this end may be accomplished, however, there remain to be worked out many problems which it seems can only be solved by the Federal Government. Congress, therefore, directed that these barge lines be retained and operated by the government even after the war.

Two problems in particular need to be solved, namely: The provision of terminal plants for transferring freight between car and barge, and the establishment of interchange products between land and water carriers, so that shipments may be routed by the shipper for movement part way by water and part way by rail. These problems being solved will enable the waterway to serve not merely communities located upon it, but inland communities as well.

Congress has already appropriated $2,000,000 to be spent within the next year in building necessary terminals, particularly along the Mississippi and Warrior rivers for the handling of waterway freight. These projects once under way must, in the opinion of General Hines, stimulate similar construction by private capital and will go far toward reducing the cost of transferring freight between car and barge.

For the New York State Barge Canal the government contracted for a fleet of 92 boats, consisting of fifty-one steel barges, twenty-one concrete barges, and twenty combined towboat and cargo barges. All of these have been delivered, with the exception of one steam barge.

For the Warrior River three steel towboats have been ordered, to be used in conjunction with twenty wooden cargo boats, capable of moving in all 10,000 tons of cargo. This equipment will be supplemented by four steel self-propelled barges, capable of transporting coal between Mobile and Violet, La., under their own power.

For the Mississippi River between St. Louis and New Orleans, the government contracted for six new power boats and forty steel cargo barges, having an aggregate cargo capacity of 80,000 tons. Some of this equipment has been delivered, but it will probably be early spring before all of the towboats will be in operation, and even then considerable time will be required in schooling crews in running them most efficiently.

The Recent Typhoid Fever Epidemic at Salem, Ohio

Water-Borne Outbreak Caused 866 Cases and 23 Deaths — Sanitary, Medical, and Nursing Activities—Downstream Protection

THE recent outbreak of typhoid fever at Salem, Ohio, attributed to the infiltration of polluted ground water into a gravity tile pipe had resulted in 866 cases and 23 deaths up to Dec. 10, when it was believed that the epidemic was at an end. The following concise résumé of the epidemic and the measures for controlling it and for the care of the sick, taken by the State Department of Health, with the co-operation of federal and local health agencies and of the Red Cross, has been prepared by the Ohio State Department of Health and sent to this journal for publication:

On Oct. 13, 1920, the health commissioner of Salem, Ohio, reported that diarrhea and enteritis was quite prevalent in Salem and environs. Dr. Charles Armstrong, epidemiological aide to the State Department of Health, was sent to Salem to investigate the source of the disease. Dr. Armstrong reported on the 16th that after very careful investigation he had found approximately 7,000 cases of a non-specific diarrhea and enteritis which were possibly due to the public water supply. An engineer from the department was at once detailed to prepare outfits for bacterial analysis, and to proceed to Salem to make a thorough examination of the water supply. On Oct. 19 E. I. Roberts, the engineer detailed for this work, reported that his analysis showed that the water supply was contaminated, and that the probable source of the contamination was located. A warning to boil all water was issued the same day to residents of Salem. At the same time F. H. Waring, another engineer of the department, started for Salem with chlorination apparatus which was completely installed and operating on the afternoon of Oct. 20. On the same day Messrs. Roberts and Waring advised the City Council to take immediate steps to permanently correct the water supply contamination. On Nov. 9 seven members of the staff of the State Department of Health were sent to take charge of the local situation. Dr. F. G. Boudreau and four members of his division were given charge of epidemiology and medical activities, while W. H. Dittoe and two members of his division had charge of water supplies and sewage disposal. R. E. Tabett, sanitary engineer, was sent by the U. S. Public Health Service to co-operate with the State Department of Health. Miss Hulda Cron, state supervising nurse, was sent later to take charge of nursing activities. The local health commissioner, Dr. R. M. Schwartz, co-operated in every way with state and federal officials, and this was true also of the local public health nursing service under Miss Donsing, and the local chapter of the Red Cross, in charge of Mrs. Smith. The local board of health, the citizens committee, and the Chamber of Commerce also co-operated fully and proved of great assistance. Other city officials, and particularly the mayor and the directors of service and safety, gave every possible aid to the campaign of prevention.

Five cases of typhoid fever occurred in Salem during August and September. These cases were widely scattered; at least two received their infection from sources outside the city, and no common source for the others was dis-

coverable. Four cases were reported between Oct. 1 and 19, but it was ascertained afterwards that over a hundred patients had taken to bed during this period. Cases came in rapidly after the 19th, and the peak of the epidemic occurred during the last week of October and first week of November. On Nov. 1 fifty-four persons took to bed with typhoid fever. After the first week in November the number of cases reported dwindled rapidly, until, during the early part of December, only scattered cases were occurring, and many of these were traceable to contact infection. The total number of cases which have occurred in the epidemic to Dec. 10 is 866, and the total number of deaths, 23. As the population of Salem is now approximately 10,000, the attack rate to date is 86 per thousand. The case fatality rate so far is less than three per cent. Eight per cent is a usual case fatality rate for water-borne typhoid fever, but it is not expected that the rate in Salem will be so high.

The Water Supply

The water supply of Salem is drawn from three groups of deep wells. Water from these wells flows by gravity into three reservoirs from which it is pumped into the city mains. One group of wells is situated in a built-up portion of the city, and the gravity line leading from these wells is of vitrified clay pipe. This line was laid in 1900, and portions of it had to be cleaned about five years ago, because of roots which had grown into it and obstructed the flow of water. The gravity lines receiving the flow from the two other groups of wells are composed of cast iron. Engineers of the State Department of Health, when examining the water supply in October, found that the water from the various groups of wells was pure, but the water in the reservoir and the distribution system was contaminated. By a process of elimination it was determined that the probable source of contamination was in the gravity tile line The water was immediately chlorinated, and the tile line was cut off above the point where a cast-iron pipe from another well entered it. Water from the wells which ordinarily discharged into the tile line was pumped directly into the mains, and the lower end of the tile line below the junction of the cast-iron pipe was replaced with a cast-iron line as promptly as possible. The reservoirs were cleaned, the distribution system flushed and all other possible precautions taken to make the public water supply safe. It must be emphasized, however, that previous to 1920 all examinations and analyses of the public water supply of Salem had shown the water to be of good quality and safe for domestic use.

Measures to Prevent the Spread of Typhoid

The following are the steps taken to control the epidemic:

(a) Sanitary Measures—1. Emergency chlorination of the public water supply. This was accomplished on October 20.

2. Installation of a permanent chlorine machine. This was done to release the State Department of Health machine for emergency purposes, and because Salem needs a permanent machine in case of any accident to the water supply.

3. Chlorination of city sewage. The sewage of Salem passes through a disposal plant but effective purification does not take place. The sewage was chlorinated to protect individuals and communities situated on the watershed below Salem.

4. All privies were disinfected by the free use of chloride of lime.

5. Use of the tile gravity line was discontinued.

6. Cast-iron pipe was laid to replace the lower end of the tile gravity line.

7. All dug wells on properties having city water service were disinfected by the free use of chloride of lime.

8. A sanitary investigation of all premises was made to determine the number of cases of typhoid fever, the number of cases of diarrhea and enteritis, the number and kind of wells, the number and kind of privies, the presence of water and sewer connections, and other useful information. This was accomplished by the war workers organization, which functioned efficiently and rapidly.

9. Inspection of all places selling food was made by the aid of six volunteer sanitary policemen. Many improvements resulted.

10. All milkmen selling raw milk ordered to have their supply pasteurized by the holding method. This was done at one of the local plants, which is large and modern in every respect.

11. All milk bottles and utensils were thoroughly sterilized at the same plant. Pasteurization of milk and sterilization of utensils were in force three days after the situation was placed in charge of the State Department of Health representatives.

12. Milkmen were forbidden to leave milk bottles at premises where typhoid fever existed. Such householders were required to place receptacles for milk on the door step.

13. All shops were forbidden to sell milk in the original containers over the counter. A notice to this effect was placed in every store where milk was sold.

14. Every house in which typhoid existed was placarded with a printed sign.

15. A printed notice to boil all water was placed in every home.

16. A printed notice on the disinfection of discharges was placed in every home.

(b) Medical Measures—1. The State Department of Health supplied large amounts of triple anti-typhoid vaccine. A sufficient amount was supplied to inoculate at least half the population.

2. The local health department provided free inoculation service.

3. Through a sum of money appropriated by the State Board of Control, at the request of the State Department of Health, free medical consultation service was provided. The internists who came to Salem for this purpose were Dr. Henry A. Christian of Boston, Drs. C. F. Hoover and Blankenhorn of Cleveland, and Dr. W. H. Bunn of Youngstown. Drs. Christian and Bunn remained in Salem as long as there was any need of consulting service. The local physicians made free use of the services of the consultants

4. Free surgical consulting service was also provided. The medical profession of Salem was quite capable of coping with any surgical emergency, but blood transfusion was advised by the medical consultants in some cases, and surgeons from the service of Dr. G. W. Crile at Lakeside were secured to group donors and perform transfusions.

5. A private duty nursing registry was provided so as to keep an adequate supply of nurses in Salem. All nurses for private duty service were required to report at the registry upon arrival at Salem and before departure. Nurses were placed in homes without regard to the financial resources of the householders. Dr. Christian commented favorably upon the fact that poor and rich alike received adequate nursing service. An incomplete census of nurses showed that at least 250 were in Salem at one time or another during the epidemic.

6. Free laboratory services were provided by the establishment of a branch state laboratory. This laboratory was established within five days after the arrival of State Department of Health representatives, and in two weeks more than 800 specimens had been examined. The work was so arranged that physicians merely telephoned requests for examinations of specimens and a technician took the specimen and sent the report to the physician. Examinations consisted of blood counts, Widals, blood cultures, urine and miscellaneous examinations.

7. A number of the patients seen by consultants were suffering severely from loss of blood, so that transfusion was advised. An appeal was put in the press for volunteer donors, and as these reported to the health department their blood was grouped and a record made of the name, address and grouping.

8. Ten actual blood transfusions were performed by members of the surgical consulting staff.

(c) Investigations—1. A sickness survey of every home in Salem was made to determine the number of cases of typhoid fever.

2. Physicians of the department investigated all reported

and unreported cases of typhoid fever for the purpose of securing epidemiological histories of each.

3. A study of the outbreak of diarrhea and enteritis was made to determine its chronology, distribution and extent.

4. The typhoid fever epidemic was studied epidemiologically as to geographical, chronological, age and sex distribution and as to possible common factors, such as public and private water supplies, milk, food and contact.

5. The municipal water supply was thoroughly investigated.

6. A study was made of the municipal sewerage system.

(d) Advice—1. Council was advised to notify riparian owners along the Little Beaver of the danger of using water from this source.

2. Council was advised to employ a competent sanitary engineer to study and plan the development of the municipal water supply.

3. Council was advised to pass and enforce ordinances governing tapping of sewers.

4. Council was advised to require the licensing of plumbers and sewer tappers to prevent careless work and the destruction of the sewerage system.

5. Municipal officials were advised to prepare and adopt regulations providing for the abandonment of dug wells where water connections are available.

6. Municipal officials were advised to adopt and enforce regulations providing for the abandonment of privy vaults where sewers are available.

7. The board of health was advised to adopt regulations governing the handling of food.

8. Advice was given to various organizations concerning the nursing situation.

9. Advice was given concerning relief measures.

10. The board of health was advised on financial measures.

11. Advice was given to various organizations concerning the hospital situation. The local chapter of the Red Cross had established three emergency hospitals. On the advice of health officials, a fourth was established. There were approximately 180 beds available for typhoid fever patients at the height of the epidemic.

By means of the measures detailed above an attempt was made (1) To abate the primary source of the epidemic. (2) To prevent the spread of typhoid fever through secondary sources. (3) To reduce the mortality by the provision of adequate nursing, medical and hospital facilities. (4) To improve permanently the sanitary conditions of Salem so as to prevent the occurrence of a similar epidemic in the future.

It is too early to decide whether all measures taken were effective, but it is possible to state that the first three objects mentioned above have been achieved. The future history of Salem will show whether the fourth item has been accomplished.

We are informed by W. H. Dittoe, chief engineer of the Ohio State Department of Health, that the City of Salem has adopted the department's recommendation as to starting plans for improvements to the water supply and that the city has engaged Morris Knowles, Incorporated, for the purpose.

Railway Work in New South Wales

About 630 miles of government railway now under construction are listed in the report of the railway commissioners of New South Wales, Australia, for the year ending with June, 1920. This mileage is divided between sixteen lines of 20 to 95 miles each, work in several cases having been interrupted for two years or more on account of the war. Shortage of explosives, cement, ties and other materials is delaying progress considerably. Preparatory work is being done for the electrification of the suburban lines near Sydney. Double tracking and four tracking of portions of the main lines is also under way.

Proposed Hudson River Bridge

Its Capacity and Cost, Compared With Tunnels, and Its Influence on New York's Transportation Problem

By Gustav Lindenthal
Consulting Engineer, New York

(Abstract of paper read before annual meeting of American Society of Mechanical Engineers, New York, Dec. 9.)

THE Hudson River is a barrier which must be crossed daily by 700,000 passengers, by 3,000 freight cars and by 8,000 to 10,000 vehicles. Of the passengers about one-half come through six submarine tunnels, four of the Hudson & Manhattan R.R. and two of the Pennsylvania R.R. All of the rest of the passengers, all vehicles and all railroad cars come over, as they did 80 years ago, on floating equipment along a river front of 12 miles. The congestion and the delays act as a deterrent to the spreading of population into New Jersey, where there is ample room within one hour's travel from New York for at least 4,000,000 people to live in surburban comfort. The two vehicular tunnels just started will, when completed in three or four years, add only four lines of traffic for vehicles, a mere drop in the bucket. The two tubes with approaches will be 10,000 ft. long and cost $28,000,000.

Compare with this backward condition the crossing facilities over the East River, for a population of 2,500,000 on Long Island. There are here besides numerous ferries four large municipal bridges (ignoring the Hell Gate railroad bridge) with, together, thirty-six tracks for rail cars and sixteen lines for vehicles, besides sixteen subway tunnels—all together, 52 lines of traffic, along a river front of only 6 miles. Two additional bridges and sixteen additional subway tunnels across the East River are under contemplation.

It is easy to see that if the 2,000,000 people in New Jersey are to be accommodated in the same proportion we must have across the North River, in addition to the above-mentioned railroad and vehicular tunnels, at least fourteen railroad tracks and twelve lines for vehicles. If put into tunnels these twenty-six lines would require twenty additional submarine tubes.

Let us assume that all these twenty tunnels would be about the same length and have the substantial construction of the Pennsylvania tunnels, or as proposed for the vehicular tunnels just started. That would make the cost of the twenty tunnels about $240,000,000.

But the higher shores of the North River above 23d Street would require most of these tunnels, with approaches, to be much longer than 10,000 ft. Some of them would have to pass under the Palisades on the New Jersey side, like the Pennsylvania tunnels, making them, with approaches, 15,000 to 16,000 ft. long, so that the total cost of these twenty tunnels would be nearer $400,000,000.

Proposed Bridge

Now let us compare these tunnels with the cost of an equivalent bridge over the North River located at or below 59th Street, where the shores on both sides are high and favorable for bridge construction.

The bridge structure and approach, beginning at Ninth Ave. and terminating on top of the Palisades, would be about the same length as the vehicular tunnels with approaches (10,000 ft.). It would have two decks, 180 ft. wide. The lower deck would accommodate eight railroad tracks, and two tracks for a moving platform, and the upper deck, for highway and local traffic, four lines of rail, twelve lines for vehicles and two sidewalks. The eight railroad tracks would connect with a two-story elevated railroad on the West Side, with the New York Central tracks along the river front, and also with a union passenger station.

The total cost of the bridge, liberally estimated, is $100,000,000, or only about one-third to one-fourth the cost of twenty equivalent tunnels.

But the bridge besides handling passenger traffic would also bring relief to seven railroad systems for the freight transfer across the river, now is exclusively done on floats.

Let us first see how the passenger traffic pouring over the bridge would be distributed at the Manhattan end so that no congestion of traffic would take place at the end of the bridge. One of the most effective means to that end would be the moving platform, requiring two tracks on the lower deck. It would be enclosed on the bridge and have a loop on the New Jersey side. Passing under 57th Street, it would have the eastern loop near the East River, adjacent to the Queensboro Bridge. It would interset every line, in subway, on elevated or on surface, running north and south, to which a passenger may change. This moving platform would take care of the local passengers within a radius of 10 min. walk on the New Jersey side.

Moving Platform Capacity

Such a moving platform at the moderate speed of 9 miles per hour would cover the distance between loops 3 miles apart in 20 min. or across the bridge in about 8 min. with a carrying capacity of 40,000 passengers per hour in each direction.

That will be sufficient in rush hours for passengers from the district at the western end of the bridge within 10 min. walking distance, when that New Jersey district should become as densely built up with tall buildings as is the lower part of Manhattan. That same distance consumes now nearly an hour, and we need not wonder that the wonderful location on top of the Palisades is so neglected. The moving platform is therefore a most important and indispensable feature of the bridge across the North River.

The eight heavy railroad tracks connecting with seven large railroad systems on the New Jersey side could be used for rapid-transit cars, for through trains of the railroad trunk lines or for freight cars, as needed.

During the rush hours these eight tracks could be used exclusively for passenger traffic. They are intended to connect with a two-story elevated marginal railroad along the west side of Manhattan down to the neighborhood of Cortlandt Street. To obtain the largest carrying capacity for these tracks they should be looped at the ends.

Later an inclined approach from the first story of the elevated railroad down a 5 per cent grade to two tunnels under the Hudson River, located near the Battery, would form a loop from the west side railroad back to the railroads in New Jersey.

The upper four tracks of the elevated railroad could in the future be continued as a marginal railroad along the East River and return to the bridge in a two-track tunnel located under the moving platform tunnel on 57th Street, above mentioned.

The transportation capacity on all railroad and rapid-transit tracks in the rush hours would be 200,000 passengers per hour. There would be on the bridge a potential transportation capacity of 500,000,000 passengers per year, not including highway passengers. On the west side elevated railroad, during the night, when travel is thin, one track each way would suffice for passenger traffic, leaving three tracks each way free for freight.

The local passenger traffic out to a distance of 20 to 30 miles in New Jersey could be kept separate without interfering with the through passenger traffic on the railroad lines, the through traffic being accommodated in a union passenger station located close to the New York end of the bridge. The rentals for offices and other accommodations would make this union station more than self-supporting.

Freight Transportation

The present number of freight cars crossing the North River averages about 3,000 per day, carrying 15,000,000 tons of freight per year, including coal. This freight traffic is growing similar to the passenger traffic, at the rate of over 10 per cent per year. At least 60 per cent of the food for a population of 6,000,000 people is brought on these railroads from the Western and Southern States. There is no room for additional railroad yards in Manhattan. Therefore it is necessary to handle that freight on the principle of the greatest expedition in unloading and loading the cars on their arrival at destination. This can be brought about through a unified management of freight delivery from all the railroads. A large classification yard would be located in New Jersey on the west side of Bergen Hill into which all the railroads would deliver their freight cars, such cars, loaded with l.c.l. freight to be unloaded directly into motor trucks. Freight would be carried on these trucks over the bridge to points of delivery in the shortest time.

Car-load freight would be taken over the bridge in short, frequent trains to elevated freight stations, not over a mile apart, located along the west side of Manhattan from the Battery to Inwood, a distance of about 14 miles. Each car being announced in advance as to time of arrival and contents, it can then be switched to short sidetracks and swiftly unloaded with facilities held ready for it. For outgoing freight such cars can at once be reloaded. Market halls, warehouses and shipping piers would also be connected to the marginal railroad.

The capacity of the bridge and stations would be sufficient to handle 2,000 freight cars per day each way, which leaves a large margin for growth. About one-third of the freight tonnage intended for Manhattan would be brought across the bridge on motor trucks. The roadway on the bridge, 140 ft. in the clear, would permit a truck movement of 6,000 tons of freight per hour in each direction, or a total of over 30,000,000 tons per year, without discommoding the tremendous automobile traffic that must be expected for passenger transportation.

Surface Car Tracks

The surface tracks on the upper deck of the bridge are intended to connect with the surface tracks on the streets and with the subways and elevated railroads in Manhattan. Their transportation capacity would be governed by the capacity of the rapid-transit lines now existing or yet to be built in Manhattan. The Ninth Avenue elevated railroad would be able to run its trains directly over the bridge into New Jersey and connect there on the Palisades with existing lines, so that residents in that section could reach the Manhattan theaters and the office and business section without changing cars.

Railroad tracks from the bridge to the tracks of the New York Central R.R. would have grades not exceeding those in the Pennsylvania tunnels. The west side elevated railroad would eliminate the so-called death avenue trouble; that is, the railroad tracks on the surface of Eleventh Avenue could then be entirely removed. Trains from the bridge would be able to turn north over a loop and without back switching to the New York Central R.R. tracks toward Inwood and Yonkers. This would be an important advantage for the delivery of coal and local freight from the railroads in New Jersey.

In laying out these plans it is expected to have the cooperation of the city authorities, who are especially interested in building market halls at short distances from each other, where the public could buy fresh food cheaply and with great convenience.

The plan here submitted looks not only to the solution of the New Jersey problem but also to the future development of the railroad terminals in Manhattan as a harmonious part of the port problem. The river piers along the Manhattan shore and along the New Jersey shore now used and occupied by railroads as passenger terminals or for freight yards would be released by the bridge and west side elevated railroad, and thus become available for ocean shipping, for which there is a great scarcity of pier accommodations along the North River. At 156th Street a connection from the New York Central tracks (connected to the North River Bridge as already stated) can be had with the Putnam division of the New York Central by tunnel near 156th Street under Audubon Park. By this short tunnel and a bridge over the Harlem River a connection can be had with the New Haven railroad system over the tracks of the Harlem division of the New York Central.

LETTERS TO THE EDITOR

Prohibition Discussion Closed

Sir—The letter by F. C. Finkle in your issue of Nov. 11, p. 957, ought not to go unchallenged. Mr. Finkle couples enlightenment with the rum bottle. The Bible and the rum bottle were carried to backward and savage races by the white race simultaneously, but one who attributes the enlightenment that ensued to the rum bottle is affected with blindness of the worst type.

On the other hand, the Koran and prohibition may have been handed to a race, as Mr. Finkle cites in the same package. The Koran countenances the greatest looseness in sexual morality (or immorality) with the result that home is a vanishing quantity or non-existent.

No argument is needed. Just a record of a few facts. But engineers, of all men, ought not to get their causes mixed. EDWARD GODFREY.

Pittsburgh, Pa., Nov. 29.

[The discussion on prohibition that has been running in these columns for some months started from a short editorial note suggested by the possible relation of prohibition in the United States to the labor supply, as the latter was affected by immigration and by the return of former immigrants to their native countries. The labor and immigration situations have both changed materially since the note was written and the letters on prohibition received and published have been getting far afield from the original note—the point of which was merely that the relation of prohibition to immigration deserved study. It therefore seems best to close the discussion, or at least to confine it closely to the original question.—EDITOR.]

The Writing of Engineering Reports

Sir—As a young engineer I have followed with much interest the discussion of Prof. Mead's recent article on the writing of engineering reports (See *Engineering News-Record*, Nov. 4, p. 891 and Nov. 11, p. 947). It has been very thought-provoking and not the least pertinent question arising therefrom is why such a discussion in the leading journal of the profession is necessary at all.

It is difficult to conceive of the leaders of the legal profession for instance, engaging in a discussion on such a subject in the columns of one of the national reviews of that profession. The lawyer is fully aware that the power of effective thought expression is his most important tool and takes for granted a thorough knowledge of its use. Why is it, then, that this question arouses so much interest among engineers who certainly occupy as important a position in our social structure and have as many points of contact with the business world as do the lawyers?

That there is a lack of understanding among engineers as to how to present facts effectively is common knowledge. One needs only to wade through the usual technical report or become acquainted with the correspondence files of the average engineering office to realize that there is such a lack of knowledge concerning the use of English as a medium of lucid expression. Certainly the discussion has been timely, but one wonders what the cause of this condition may be.

There is no magic touch required in formulating a technical report. Technical writing, like every other kind of serious writing, has as its avowed purpose the conveying of information and the influencing of the reader to adopt a definite mode of thought or action. As such it is grounded on the same fundamental principles of composition as any other kind of exposition. A salesman would probably express these principles as "the selling point of view," which rests on two commonsense propositions, first, knowing ones product or subject and second imagining oneself in the position of the probable reader or client. The first requisite insures clearness. Clear and logical statement of facts results only where there is clear and logical thinking. The second insures effective arrangement of facts in the form most convenient for the client. The writer should keep constantly in mind that the report is for the client's use and the arrangement should be decided upon with a view to making it less difficult for him to arrive at an intelligent conclusion, which, after all, is the real purpose of the report.

A working knowledge of these fundamental principles is the primary aim of every English course in our schools and universities and it would seem that if the engineer lacks understanding of this important part of his equipment there has been something lacking in his education. It seems a little unfair perhaps to blame our already overburdened technical schools, but since they are the chief agency in the training of engineers they must assume some of the responsibility. Recently, the writer had occasion to look through the curriculum of a half-dozen or so of our representative technical schools and found that no radical change in the arrangement of the course of study has been made in the several years since he was more intimately acquainted with one of them as an undergraduate. In only one of those examined did he find a study of the "King's English" given more prominence than a few cursory hours in the freshman or sophomore years. This notwithstanding the fact that the engineer's non-technical principal will judge him and his success will be largely determined by his ability to give clear and effective expression to his thought. With this slight on the part of those who form the courses of study is it any wonder that the average undergraduate in a technical school has a contempt for such study and that he frequently leaves school with a pathetic lack of knowledge as to how to express his thoughts effectively? We cannot expect to find a man fresh from the technical school a finished engineer, but it is not too much to expect that he have a good educational and cultural background for his engineering knowledge which, in any event, he will have to supplement in large measure by experience and subsequent study. Without these fundamentals and possessing an indifference toward acquiring them he may still become a skilled craftsman but will hardly be credited by his associates with being a member of a learned profession.

It will be interesting to note as our system of technical education develops, how our engineering schools will cope with this reality; whether by giving these subjects more prominence at the expense of more technical studies; whether by a lengthening of the course of study beyond the limits of the customary four years or whether as has been resorted to by leading schools of other professions, by making as a prerequisite for entrance the completion of certain work in a college of Liberal Arts.

Engineers have a right to expect our technical schools to actively interest themselves in the advancement of the interests of the profession not only by developing and disseminating technical knowledge but by giving the young engineer that professional pride and vision which will make him ashamed to show an ignorance of the art of effective thought expression. How they function in bringing the young engineer to realize the relative importance of this useful art will have a great deal to do, it would seem, with determining whether or not engineering is to be recognized and respected as being on a par with the other so-called learned professions. W. N. MITCHELL,

Assistant Engineer, the A., T. & S. F. Ry.

Topeka, Kan., Dec. 10.

Taking Advantage of Truck Accidents

To reduce coal-trucking costs George S. Pope, chief engineer of the Government fuel yards in Washington, D. C., has instituted the practice of taking pictures of the mishaps which his trucks suffer and posting them on a bulletin board at the fuel yards as an object lesson to the drivers. That the lesson is effective is evident from the fact that the truck drivers early in the work referred to the pictures as "the rogues gallery." In future the driver who meets with the accident will be required to stand in front of his truck so that he will be pictured along with his unhappy situation.

HINTS FOR THE CONTRACTOR

Heavy Bar Bender Devised From Old Steam Shovel Parts

BY ARTHUR H. LYNCH
Brooklyn, New York

WITH the air cylinder, rack and spur wheel from a discarded steam shovel the bar-bending machine shown by the illustration was devised for the steel yard of the navigation canal and inner harbor works at New Orleans. Bars from the stock shed at the far end of the view move ahead on roller tables to the shears and thence to the bar bender. A heavier timber

JOB-BUILT BAR BENDER FOR HEAVY WORK

table carries the bending machine. Essentially this consists of a rotating horizontal spur wheel, with an upstanding hub and an attached dog between which the bar is bent. The spur is rotated by compressed air through the agency of the cylinder and rack. Variation in the diameter of the hub collar and the position of the dog provides for different radii of bends. Most of the steel used is 1¾-in. diameter round bars and these have been bent successfully in great numbers.

Steam Shovel Sparks Cause Premature Blasts

BLASTING rules have been formulated by the U. S. Bureau of Mines to avoid danger of premature explosions by sparks from steam shovels. Accidents due to this cause have been frequent and from a study of them precautions are suggested as follows:

(1) The general principle should always be followed that workmen should never be allowed at the base of a quarry face within the zone of possible danger from falling rock after the work of loading the hole has begun, and the presence of workmen in the area between the line of holes and the face should be avoided.

(2) Before loading is begun, the steam shovel and locomotives should be withdrawn from the face of the quarry to such a distance that under no circumstance could sparks from them be carried to the explosive in the holes or on the ground above or around it, or if such equipment is not removed it should not be operated.

(3) If there is any unavoidable danger from sparks or cinders, a canopy should be provided which will protect the explosive from flying sparks. A covered hopper may be used for black blasting powder.

(4) Where an unexploded charge is uncovered by the steam shovel, operations should cease until all of the explosive has been recovered and removed to a safe distance.

(5) Every piece of paper or other inflammable material should be removed from the vicinity where explosives are placed during loading operations.

(6) Primers should be kept in a portable metal box with a hinged cover and should not be stored close to the explosive, especially while the holes are being loaded.

(7) Unopened boxes of explosives should not be stored close to the hole being loaded, but should be opened at a distance from it and brought up as needed.

Gravity Track Distribution Reduces Cost of Earth Fill

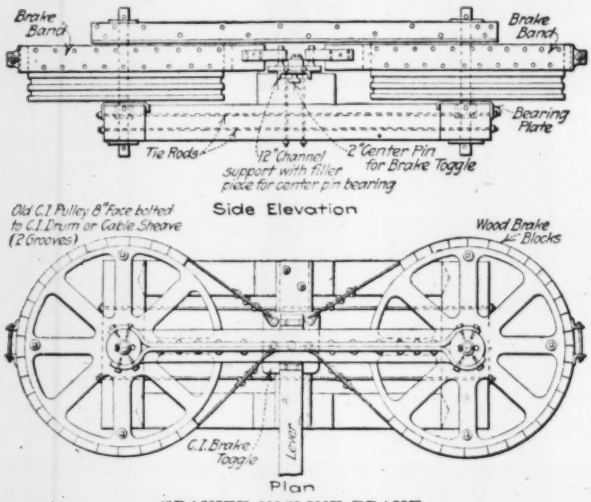
BY DONALD G. COOMBS
Office Engineer, Braden Copper Co., Rancagua, Chile

DISTRIBUTION of 50,000 cu.yd. of earth from a cut at high level to a fill at lower level, was successfully accomplished by a cube incline and gravity tracks, in building the smelter for the Braden Copper Co., at Caletones, Chile. The construction required the excavation of approximately 300,000 cu.yd. of material from four different levels. The fifth, or lowest level, was entirely fill, 90 per cent being from the second or 5,139-ft. level. Unlike the 5,073-ft. and 5,105-ft. levels, where the cut and fill nearly balanced, the 5,139-ft. level was practically all cut. With railroad or team equipment available, the greater part of the excavated material could have been used for extending this and the 5,150 ft. level and in making other levels or "canchas" east of the cut. But, with the only available equipment consisting of some few 24-in. gage, ¾-cu.yd. capacity V-body, Koppel cars and a dozen 30-in. gage, 4-cu.yd. standard Western dump cars, the most economical procedure seemed to be that of a gravity incline from the 5,139-ft. level cut to the 5,061-ft. level fill.

For this purpose an incline brake was borrowed from the Mining Department and set up at the head of the incline on the 5,139-ft. level. This brake is shown in detail by the sketch. As the incline had an 11 per cent grade, the loaded car going down furnished a surplus of power over that required to pull up the empty, so that considerable braking was necessary to control the speed. Forty-pound rail was used, and being scarce, a three-rail track was laid, with the middle rail common to both the up and down tracks excepting for the passing tracks at the middle point of the incline. By the use of spring switches the full and empty cars automatically took their respective tracks. (The more automatic devices one can install the less provocation one will have for wanting to take a pick handle to the South American laborer.)

In beginning the cut, two 18-ton, revolving, traction-type steam shovels were employed and the four-yard cars were moved to and from the head of the incline by horse and man power. Later, as the cut deepened and one shovel was used elsewhere, the cars were

spotted and loads hauled to the incline by means of a two-drum steam hoisting engine set at right angles to the incline. Curves in the pit tracks were negotiated by means of snatch-blocks anchored to deadmen, and by using one drum for the loaded and the other for the empty cars, it was seldom necessary to take the cable out of the blocks excepting for moves and track changes. Until it was learned, from experience, that the success of an incline is directly proportional to the amount of work put on the track, derailments were frequent. The economical operation of a gravity incline requires a well-ballasted and aligned track. No one was allowed to ride the cars. From the foot of the incline the cars were handled on the dump by two-horse teams equipped with special "stretchers."


Brake Band
Brake Band
Bearing Plate
Tie Rods
12" Channel support with filler piece for center pin bearing
2" Center Pin for Brake Toggle
Side Elevation
Old C.I. Pulley; 8" Face bolted to C.I. Drum or Cable Sheave (2 Grooves)
Wood Brake 4" Blocks
C.I. Brake Toggle
Lever
Plan

GRAVITY INCLINE BRAKE

With one shovel, an average of sixty 4-cu.yd. loaded cars per 9-hour day was handled over the incline and there were a number of days when a rate of 15 cars an hour was maintained. The material varied from loam through clay and boulders to hard-pan and shattered rock, so that considerable drilling and blasting was required. For this reason delays in the pit, rather than the capacity of the incline, were the limiting factors.

AVERAGE COST OF EXCAVATION AND FILL FOR SIX MONTHS EXCLUSIVE OF OVERHEAD

Detail	Labor	Material	Total
Drilling and blasting	$0.06	$0.04	$0.10
Steam shovel excavation	.09	.21	.30
Operating hoist and brake	.02	.06	.08
Laying and maintaining track	.04	.02	.06
Operation and maintenance of dumps	.13	.02	.15
Drainage	.01	...	.01
Field superintendence	.01	...	.01
Maintenance of equipment	.03	.06	.09
Plant Arbitrary	...	.10	.10
Cost per cu. yd. in fill	$ .39	$ .51	$ .90

For six-months' operation, the average cost by items of material in the fill is given by the accompanying table. The crew was in charge of a shovel foreman at $175 a month and he had two sub-foremen, one on the dump and the other in the shovel, pit. The average wages paid at that time are, in Chilean currency (exchange 3:1):

Common laborer	$4.50	Shovel runners	$16.00 to $18.00
Pitmen	$5.00 to 5.50	Shovel firemen	6.00 to 8.00
Hand drillers	5.50 to 6.00	Shovel cranesmen	6.00 to 9.00
Teamsters, 2-up	5.00 to 6.00	Hoist engineers	7.00 to 8.00
Special laborers	5.00	Cabos	10.00 to 14.00

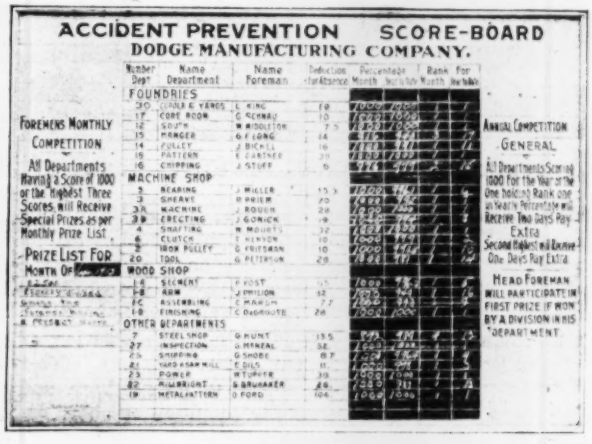
Coal (briquetted) averaged $32 per ton; lubricating oils 90c. per gallon 4 in. x 6 ft. sawn Roble ties 85c. each; track spikes and bolts 20c. per pound (when one could get them); and other supplies in proportion. The material prices are given in all cases in United States currency.

The entire construction program was under the supervision of Mr. E. H. Baldwin, assistant consulting engineer, with R. E. Post, division engineer in charge of the Caletones construction. J. G. Johnson, general foreman, had charge of all steam-shovel excavation. The writer was assistant division engineer.

Score Board Record Reduces Industrial Accidents

COMPETITION in accident prevention, between different factory departments of the Dodge Manufacturing Co., has been materially increased by using the score board illustrated. To display the record and names the board was made large (24 x 17 ft.) and was located at the main factory gate. A simple scoring mechanism was sought: (1) The starting point is 1,000 for both year and month; (2) each division is penalized according to its accidents; (3) each day's absence bears a percentage charge in proportion to the total number of man-days per month per division. A feature is a system of reward, which has helped to maintain interest.

It is stated that as a means of preventing accidents the score board has rendered excellent service. It is no uncommon occurrence to have 10 divisions out of 26 showing perfect scores. Included in some of the perfect scores is the steel foundry where castings weighing as high as 50 tons are made. This work is usually classed as hazardous. Some divisions have perfect scores year after year and there is hardly a single division that has not shown a marked decrease in accidents during the past eight years.


ACCIDENT PREVENTION SCORE-BOARD
DODGE MANUFACTURING COMPANY.
FOREMENS MONTHLY COMPETITION
All Departments Having a Score of 1000 or the Highest Three Scores will Receive Special Prizes as per Monthly Prize List.
PRIZE LIST FOR MONTH OF
GENERAL
ANNUAL COMPETITION
All Departments Scoring 1000 for the Year or the One holding Rank one at Year's Percentile will Receive Two Days Pay Extra
Second Highest will Receive One Days Pay Extra
HEAD FOREMAN WILL PANTICIPATE IN FIRST PRIZE IF WON BY A DIVISION IN HIS DEPARTMENT

SCORE BOARD FOR RECORDING ACCIDENTS

German Reinforced-Concrete Water Tank

Elevated water tanks of reinforced-concrete have been built recently in Germany. As described in a German paper, the largest of these has a total height of 200 ft., made up of a 164-ft. tower and a top tank 36-ft. high. In addition to the upper tank there is a tank at the ground, the bottom of which forms the footing base for the tower. There are also intermediate tanks. The bottom tank has a capacity of 132,000 and the next succeeding tanks have capacities of 17,000, 53,000, 132,000 and 262,000 gal. respectively.

NEWS OF THE WEEK

New York, December 23, 1920

Federation's Board Meets, With Hoover Presiding

Committees Named — Immediate Program Considered—Sum of $1,000 Authorized for Publicity

Herbert Hoover, president of the Federated American Engineering Societies, presided at the executive board meeting of the American Engineering Council of that organization, held in New York, Dec. 17. Every member of the Council was present, with the exception of A. M. Greene, and two new members of the board were elected, W. B. Powell, of the Buffalo Engineering Society, representing District 1 (New York and New England States), and Gardner S. Williams, Grand Rapids Engineering Society, representing District 2 (Michigan, Wisconsin and Minnesota). The president appointed the following standing committees:

Procedure — Calvert Townley, chairman; Herbert Hoover, ex-officio; W. E. Rolfe, D. S. Kimball, J. Parke Channing, L. W. Wallace, L. P. Alford.

Constitution and By-Laws—W. B. Powell, chairman; C. F. Scott, D. S. Kimball.

Publicity and Publications—L. P. Alford, chairman; H. W. Buck, H. E. Howe.

Membership and Representation—J. F. Oberlin, chairman; L. W. Wallace, A. S. Dwight.

Finance—William McClellan, chairman; E. Ludlow, C. Townley, L. W. Wallace, ex-officio.

Public Affairs—J. Parke Channing, chairman; Fred J. Miller, L. B. Stillwell.

In discussing the program of the Council immediately ahead, Mr. Hoover stated that he had called engineers together in various cities he had visited lately and that he found that the general desire of engineers everywhere was to join the federation movement, but that the trend was for territorial organization, as distinguished from national organization. One of the stumbling blocks in the way of these territorial organizations joining the national organizations was the question of dues. Another complexity was that individuals hold memberships in more than one society. For example, the Western Society of Engineers has about 4,000 members, of which 3,000 are already members of national societies who have affiliated with the federation. Mr. Hoover also stated that there had been some opposition to the federation based on the constitution, but that the question of territorial organization was the most important, and he suggested that

(Continued on p. 1253)

State Highway Officials Urge Federal Aid

Appear During Washington Convention, in Hearing Before House Committee on Roads—W. S. Keller, Elected President

DEFINITE progress in securing continued federal aid in highway construction was made at the annual meeting in Washington, D. C., Dec. 13-16, of the American Association of State Highway Officials. Traffic problems, including regulation of vehicle loads, classification of roads and road types in relation to traffic service value, were constructively discussed. Foundation design and structure were emphasized as the primary construction problem of the future. Delegates from 35 state highway departments participated in the proceedings.

Federal Aid Promoted

Inspiration to the legislative work of the meeting was received in the opening address of the Hon. E. T. Meredith, Secretary of Agriculture. In his annual report just completed, Secretary Meredith announced, he had urged Congress to enact immediate legislation to continue federal aid beyond June 30, 1921, when the aid provided by the present act terminates. Specifically, he had recommended that, beginning with the date named, $100,000,000 a year be expended in federal aid for five years under substantially the terms of existing legislation. The necessity of this legislation he had considered to be immediate, so that there might be no break in the program of road improvement and so as to permit of participating legislation by the forty state legislatures to be in session this winter.

Developing the statements of Secretary Meredith, Thomas H. MacDonald, Chief of the Bureau of Public Roads, summarized the federal-aid work. An even greater accomplishment than the absorption of the present appropriations by construction completed and in progress and by projects approved, he said, had been the development of state highway legislation and the creation of public sentiment favoring highway development.

A resolution submitted by C. M. Babcock, Minnesota, called upon the executive committee, with the aid of a supplementary committee of five, to urge upon Congress the enactment of federal-aid legislation. At a meeting of this committee on Dec. 14, a program of action was planned, speakers were appointed and on Dec. 15, the committees, supported by a delegate from each highway department represented at the meeting, appeared before the Congressional Committee in formal argument for the legislation requested. This prompt action of the association and its favorable reception was the outstanding constructive work of the convention.

Traffic Problems

Traffic in its relation to highway planning, construction and maintenance proved a subject so interesting that its consideration had to be curtailed because of time limitations. A paper on "Traffic Census," by A. N. Johnson, Maryland, presented at the opening session, was the forerunner of a series of papers and discussions which occupied the entire five hours' session of the second day of the meeting and then had to be terminated by the chairman's gavel.

Prefacing an appendix which summarized traffic census methods and results in the several states and reviewed practice in foreign countries, Mr. Johnson commended in particular the practice in Maryland, which is distinguished by the careful classification of vehicles, some twenty classes being recorded.

Criticism of this elaborate classification was made by A. W. Dean, Massachusetts; it was too complex, he believed, to be recorded accurately by the character of census takers ordinarily employed and in the time available. Five classifications, he considered, would furnish all the information obtainable from mere enumeration and would be all that the census takers could record with any degree of accuracy. In any event, weight of traffic and not the number and class of vehicles was the fact to be determined. In Massachusetts weights were ascertained using loadmeters to determine separately the rear axle and front axle loads. These weight records had shown that overloading was common practice; in some instances the overload was as much as 250 per cent. Under such conditions any classification of vehicles on the basis of assumed loads gave census records of comparatively small value. Finally a traffic census was of slight usefulness in deciding on types of surface.

Uniform state laws limiting the loads on vehicles were urged in a paper by C. J. Bennett, Connecticut. With uniform laws enacted, the second step was to enforce the laws. In discussion, Thomas Maddock, Arizona, expressed general agreement, but he pointed out that it might be better to put money

into roads which would carry heavy traffic than into policemen to prevent heavy loads from being carried. Speaking in a similar mood, J. N. Cole, Massachusetts, urged that in considering load limitations, the economic outlook should not be confined to load effects on road structure. He instanced occasions last winter when, owing to railway blockades, heavy trucks, which undoubtedly damaged the roads, were the only means of preventing mills with thousands of employees from closing because of lack of dyes. Road officials, he thought, should be careful not to acquire the habit of thinking of highways as sacred to all but defined traffic.

Two methods of regulating vehicle loads were proposed: First, to charge a license proportional to the damage and, second, to limit weights by law. High fees, said J. A. Mackall, Maryland, had never prevented the use of heavy trucks. The only preventive was to set limits of weight and enforce the regulation. In Maryland, trucks were weighed, compelled to take off the overload, even if it had to be piled on the roadside and then were fined. Where formerly 50 or 60 overloaded trucks were apprehended each day, now the arrests were one or two or none. By shifting the weighing operations from one road to another, without notice or regularity, no extensive policing force was necessary.

Road Structure

Discussion of papers, by A. T. Goldbeck, Bureau of Public Roads, on researches leading to the adequate design of road surfaces for heavy motor trucks; by C. M. Upham, state highway engineer, Delaware, on study and treatment of subgrade and foundation; and by A. R. Hirst, state highway engineer, Wisconsin, on relative service values of different types of pavement (see *Engineering News-Record*, Dec. 16, p. 1187) indicated a pronounced trend of thought toward greater consideration of foundation construction and less concern about types of surfacing.

Road design, stated W. D. Uhler, Pennsylvania, had to be based on foundation conditions. Sub-grades must be studied in respect to drainage, soil treatment to reduce capillarity, compactibility of soil, and treatment of variable materials. Service studies were superior to laboratory tests. Capillarity of soils as a foundation problem, was further stressed by C. M. Upham, Delaware, and Clifford Older, Illinois. Mr. Upham believed that when subsoils had this property to a high degree stability could be secured only by replacing the original soil with a foundation of stable material or by so treating the original soil as to render it stable by reducing its capillarity.

Observations and tests of soil capillarity in Illinois were cited by Mr. Older as indicating that a safe pavement slab could be designed only on the assumption that it was a floating structure. With the best possible drainage, capillary seepage of water would, with two to four days' rain, render the subgrade surface directly beneath the slab practically a liquid in respect to its function as a pavement support. An experimental road had been built and a series of observations and tests planned for the purpose of arriving at definite determinations.

Transportation Conditions

There is a fair possibility that there may be improvement in the railway transportation of road materials during 1921. Speaking for the railways, a representative of the car service commission stated that the coal situation being now in hand, there was a surplus of cars resulting (1) from more efficient operation and (2) from the stagnation in business. "It seems reasonable to assume," he said, "that road builders will have improved railway service next season."

Cost-Plus Contracts Advocated

Modification of contract requirements to meet present conditions was urged by W. R. Neel, Georgia, in reciting the successful experience this season with a cost-plus contract. An outline of this experience will be published in a future issue of *Engineering News-Record*. In discussion, F. S. Greene, New York, took a positive stand in favor of cost-plus contracts and state purchase of materials, wherever the state laws would permit these practices. There was a shortage of contractors; contractors must be encouraged, and the cost-plus contract, Mr. Greene said, promised to do this and in addition offered opportunities for economy.

Federal Aid Resolutions

Three resolutions were passed all calling for federal aid of some sort. (1) Continuance of federal aid on the basis of present legislation with certain modifications (McArthur bill); (2) appropriations by the Secretary of Agriculture of money for research on the basis of equal appropriations by the state; (3) legislation providing for further distribution of surplus war materials.

Yards and Docks Bureau of Navy to Spend $21,000,000

The public works program of the Bureau of Yards and Docks of the Navy Department calls for the expenditure of $20,993,500 during the next fiscal year. The larger items are as follows: For repairs and preservation, Navy Yards and station, $5,000,000; marine barracks, San Diego, $500,000; naval base, San Diego, $250,000; naval base, Hampton Roads, $145,000; permanent training station, San Diego, $1,000,000; depots for coal, $1,836,000; naval ammunition depot, Pearl Harbor, Hawaii, $342,000; naval station, Pearl Harbor, $1,946,000; naval station, Guam, $1,499,000; naval station, Cavite, $964,000; Navy Yard, Philadelphia, $730,000; Navy Yard, Norfolk, $315,000; naval station, Key West, $800,000; Navy Yard, Mare Island, $480,000.

Protection for City Engineers Against Investigators

A decision involving the right of inspection of public records has just been returned by the District Court of Appeals for the First Appellate district of California, which is regarded as a victory for the San Francisco city engineer's office. Commenting on the decision, M. M. O'Shaughnessy, city engineer, says: "This indicates that there is more or less protection for engineers and other officials engaged in public work and assures them of an opportunity to at least complete their investigations and studies and to make a formal report thereon before citizens or professional investigators can gain access to the data they have collected for the purpose of criticism or attack."

The case came up in connection with work on the Hetch Hetchy project on which preliminary and uncompleted data, maps, plans and specifications relating to the construction of dams and tunnels had accumulated in the city engineer's office. Prior to the time the data had been finally passed upon or approved and transmitted to the board of public works for formal action, the Municipal Research Bureau demanded the privilege of inspecting this data. The city engineer, saying that he was "somewhat suspicious of the methods of the petitioning bureau and its incorporators," refused to grant the privilege and an appeal was made to the court for a writ of mandate.

Claim was made by the attorneys for the city that certain of this data was in the nature of privileged communications involving matter to be used in litigation. The trial court granted the petition for writ of mandate for inspection but excepted data which was in the nature of privileged communications to attorneys. Both sides appealed, the city officials claiming that none of the preliminary and unapproved data should be considered as a public record.

The decision of the Appellate Court upholds the city's contentions with reference to the character of the preliminary and unapproved data, but also holds that the language of the court excepting all data claimed as privileged communications was too broad. However, as all of the data which was in dispute comes within the preliminary and unapproved category, the net result of the judgment sustained the city engineer in his refusal.

Gift for Engineering Research

A contribution of $200,000 has been made by an anonymous donor to the Engineering Foundation, which organization is trustee for the fund of $300,000 given by the late Ambrose Swasey as the beginning of an endowment for research work in science and in engineering. The Engineering Foundation, of which Charles F. Rand is president, and Arthur D. Flinn is secretary, is proposing to increase the endowment fund to $5,000,000. It amounts at present to $500,000.

Moving Pictures for Highway Transportation Show

Moving pictures are to feature the highway transportation show which is to be given under the auspices of the Motor Truck Association of America in the 12th Regiment and the 1st Field Artillery Armories, New York City, January 3-8, 1921. Among the pictures to be exhibited are those depicting the workability of the motor truck; the various uses to which the motor truck is put in highway transport; the construction of roads; tests upon motor trucks for the determination of impact and weight distribution; the care, repair and adjustment of truck parts; and the abuses to which pneumatic and solid tires are put.

Federation's Board Meets

(Continued from p. 1251)

a committee should be appointed to canvass and help the situation. This question was discussed and referred to a special committee, which will include the six district delegates.

As a step forward in co-ordinating various inter-society activities already established, the necessary action was taken to make it possible for certain of the activities of Engineering Council to be taken over by the new organization. Section 9, Paragraph 6 of the by-laws was amended so that members of committees can be selected from societies other than those at present members of the federation. Civil engineers and engineers in other bodies not at present affiliated with the Federated American Engineering Societies can, because of this action, co-operate in the committee work.

The four so-called founder societies in addition have been associated in a common employment service and the American Engineering Council has offered to take over this service as a part of its function.

The American Engineering Council voted not to affiliate with the United States Chamber of Commerce. It was the thought of the meeting that the Council could make its best contribution to the public by acting independently.

The Council authorized the appropriation of $1,000 as an initial fund to carry on publicity work, and the committee on publicity and publications was given authority to set up a board of engineering editors.

It was voted that full expenses of members of the executive board for attendance at meetings would be paid.

A special committee reported on candidates for permanent executive secretary of the organization, but no final action on the appointment of this officer was taken at the meeting.

There was a general feeling expressed that the meetings of the board should be held at different centers, and the place of the next meeting, which will be held Feb. 11, was left to the discretion of the president.

New York Section of Am. Soc. C. E. Discusses Port Problem

The problem of the port of New York was broadly discussed by ten engineers and port authorities at the meeting of the New York Section, American Society of Civil Engineers, Dec. 15. Communications from four others were read. The meeting was presided over by Colonel W. J. Wilgus, president of the section, who outlined the subjects requiring consideration. The principal paper was presented by B. F. Cresson, Jr., chief engineer, New York-New Jersey Port and Harbor Development Commission. In the discussion which followed a debate took place between Murray Hulbert, commissioner of docks, New York City, and Julius Henry Cohen, counsel of the joint commission, on the effect of the proposed port treaty between the two states. A report of the technical discussion and an abstract of Mr. Cresson's paper appear elsewhere in this issue.

Hold Conference for Operators of Iowa Sewage Plants

To encourage better operation of sewage disposal plants in Iowa and to stimulate and train operators was the purpose of the second state conference on the operation of sewage disposal plants held Dec. 9 and 10 at Iowa State College under the auspices of the department of engineering extension, for which R. S. Wallis is municipal engineer. The papers related to the more ordinary features of sewage problems. Prof. J. H. Buchanan spoke on "The Composition of Sewage"; R. S. Wallis on "The Methods of Sewage Disposal" and on "Upkeep"; Dean Anson Marston on "The Relation of Sewage Treatment to Water Purification"; P. F. Hopkins on "Grit Chambers"; Prof. C. S. Nichols, on "Sewage Screens" and "Industrial Wastes"; Langdon Pearse on "Sewage Sedimentation Tanks and Their Operation" and on "Modern Plants"; L. E. Rein on "Sewage Dosing Chambers and the Care and Operation of Sewage Siphons"; C. H. Currie on "The Construction of Intermittent Sand Filters"; Prof. Max Levine on "The Role of Bacteria in Sewage Disposal"; Lafayette Higgins on "The Operation of Intermittent Sand Filters" and on "Sludge Disposal"; Prof. J. H. Dunlap on "Inspection Experiences"; Prof. M. L. Evinger on "Construction and Operation of Trickling Filters and Contact Beds."

In addition to the discussion of the papers operators stated their experiences in scraping and maintaining sand filters and quick tests for good drying sludge. A demonstration of sewage bacteria was given in the laboratory.

Albert A. Bowman Sought

It has been requested that *Engineering News-Record* publish the following note: The friends of Albert A. Bowman, formerly of 2 Charter Oak Ave., Hartford, Conn., desire to get in immediate touch with him.

Civil Engineers Reverse Action On Engineering Council

After having passed on Nov. 9 a resolution opposing the discontinuance of Engineering Council, the executive committee of the Board of Direction of the American Society of Civil Engineers, at a meeting held Dec. 6, reversed its prior action and authorized its representatives to join with the majority of the member societies in terminating the existence of Engineering Council. The resolution of Dec. 6 is as follows:

Whereas at its meeting Nov. 9, 1920, the Board of Direction instructed its representatives on Engineering Council to express to Council its hope that Engineering Council, for the present, continue to carry forward its work; and

Whereas it now appears that the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers may, as a consequence of their having joined the Federated American Engineering Societies, discontinue their participation in the work of Engineering Council;

Be it resolved, That the representatives of this society on Council are hereby authorized to join with a majority of the member-societies in action to terminate the existence of Engineering Council at the end of the present calendar year, with the provision that in case of termination of Council the interests of the society shall be properly secured in whatever disposition may be involved of Council's property and records.

Bridge Committee Appointed by Civil Engineers

In response to requests from the membership the Board of Direction of the American Society of Civil Engineers has created a special committee on bridge design and construction, to consist initially of the following members: Howard C. Baird, J. E. Greiner, C. W. Hudson, M. S. Ketchum, B. R. Leffler, A. F. Robinson, H. B. Seaman, F. E. Turneaure, and J. R. Worcester. The committee "shall, as need develops, make recommendation to the board of additional members" required.

Effective correlation of the work of this new committee with bridge specification work by other societies is expected. The Board of Direction in a special resolution expressed its desire that the committee should confer and co-operate with similar committees of other societies, naming specifically the American Railway Engineering Association and the Engineering Institute of Canada.

Civil Engineers Announce Annual Meeting for Next Month

The sixty-eighth annual meeting of the American Society of Civil Engineers will be held at the headquarters of the society, 33 West 39th Street, on Wednesday and Thursday, Jan. 19 and 20, 1921. The business meeting will be called to order at 10 o'clock on Wednesday morning. The annual reports will be read; officers for the ensuing year elected; members of the nominating committee appointed; reports of special committees presented, and other business transacted.

The arrangements for excursions and entertainments will be announced later.

Municipal Engineers of New York Give Dinner to N. P. Lewis

In recognition of the retirement of Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of New York City for the last eighteen years and in the service of that city and of Brooklyn for thirty-six years (see *Engineering News-Record*, No. 18, p. 1011), the Municipal Engineers of New York gave a dinner on Dec. 18 which was attended by some 350 members and guests. Addresses were made by F. H. La Guardia, president of the Board of Aldermen, by the Rev. Dr. Berg, pastor of Mr. Lewis' church, by George McAneny, formerly president of the Board of Aldermen and acting mayor, and Charles Whiting Baker, until recently consulting editor of *Engineering News-Record*. The speakers laid stress on Mr. Lewis' high character, tact and conspicuous engineering ability.

Dr. Berg and Mr. McAneny dwelt on Mr. Lewis as a city planner, active in New York City and prominent nationally and internationally. Mr. Baker, in speaking of Mr. Lewis as an engineer, defined an engineer as "a man who sees the end from the beginning" and said that the definition was particularly applicable to Mr. Lewis.

Pittsburgh Society Affiliation Under Discussion

In Pittsburgh the various engineering societies are now considering proposed by-laws for an organization to be known as the "Associated Engineering Societies of Pittsburgh." It would be composed of the Engineers' Society of Western Pennsylvania and of the Pittsburgh sections of the national societies of civil, mechanical, electrical and of mining and metallurgical engineers. Thus far, the civil and mechanical sections have approved of the proposed by-laws and so has the board of the Engineers' Society of Western Pennsylvania. The purpose of the organization would be to secure joint action on matters of common interest. Other engineering organizations would be eligible for affiliation later.

Official Population of the United States Announced

The population of continental United States as of Jan. 1, 1920, has been announced by the director of the census as 105,708,771 and of its outlying possessions as 12,148,738, making a total of 117,857,509. Of the outlying population the Philippine Islands (as of Dec. 31, 1918) has 1,035,640 population; Porto Rico, 1,299,809; Hawaii, 255,912; Alaska, 54,899; Virgin Islands of the United States (Nov. 1, 1917), 26,051; Panama Canal Zone, 22,858; Guam, 13,275; American Samoa, 8,056; military and naval service abroad, 117,238. The population of continental United States in 1910 was 91,972,266 and in 1900 it was 75,994,575, the percentages of increase for the corresponding decades being 14.9 and 21 per cent.

Engineers' Club of Baltimore Reorganizing

The Engineers' Club of Baltimore is reorganizing to include, in a membership of 600, not only technical engineers, but also business men in firms doing work involving engineering. The local sections of the following societies have already affiliated with the engineers' club: American Society of Civil Engineers, American Association of Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Chemical Society. New quarters have been secured in the Merchants & Manufacturers Building. According to announcement of the club it will undertake consideration of civil problems, including industrial and shipping growth of Baltimore, harbor development, housing, city planning of annexed districts, water supply and other public utilities.

Open-Shop Combine Charged Against Steel Producers and Erectors

Evidence that various steel fabricators had during the past year followed a policy of refusing to sell structural steel to any but those who would erect under open-ship conditions produced the outstanding feature in the past week's investigation of housing conditions in New York City by the Lockwood joint legislative committee on housing. Among the steel fabricators mentioned in the testimony taken on this subject are the United States Steel Corporation, the American Bridge Co., a subsidiary of the steel corporation, the Bethlehem Steel Corporation, and others. It is alleged that this open-shop combine existed between these various fabricators and erectors associations, including the National Erectors Association and the American Erectors, the two leading national steel erectors, associations.

It is estimated that at least two weeks will be consumed yet in the investigation of labor and construction conditions in the building industry before the Lockwood committee will be able to take up banking and insurance features. It is likely that an investigation will still be made of the Building Trade Employers' Association and its connection with organized labor, and of alleged combinations of dealers and contractors in glass, plumbing supplies, terra cotta, pipe, electrical supplies, and lumber.

Another Chicago Subway Project

An 18-mile subway system proposed by the Chicago traction commission would begin in the business district and extend west under Madison St. to Ashland Ave., where lines would diverge to the northwest and southwest sections, with loop terminals at Lawrence Ave. and 63d St. respectively. Plans have been prepared by G. W. Jackson, engineer for the commission.

Bottom of Depression Nearly Reached, Says Chamber of Commerce

The bottom of the present business depression will be reached in the next thirty days, in the opinion of Archer Wall Douglas, chairman of the committee on statistics and standards of the Chamber of Commerce of the United States, in his monthly report on general business conditions, made public Dec. 21 in *The Nation's Business*.

"Advances of any moment in the prices of agricultural products," says Mr. Douglas, "will materially change the situation for the better, and reductions in the prices of commodities are likely to cause increased business in all industrial sections." Acute phases of the present depression will wear away steadily as the public adjusts itself to changed conditions brought about by a return to normal. Unfavorable agricultural situations, especially, have an unexpected way of remedying themselves.

"From the unfounded fears of last spring of bread lines in the cities and shortage of food everywhere, we are awakened to the startling realization of a harvest so great that we cannot at once find an adequate market for our surplus products. So there ensues that inexorable law of supply and demand which decrees that overproduction is always accompanied by falling prices.

"There is a general belief that there will be a revival of building in the spring, because conditions will be more favorable, and the necessities of the situation are more pressing."

Board of Estimate Recommends Contracts Be Cancelled

The Board of Estimate and Apportionment of New York City has approved the recommendation of Corporation Counsel O'Brien for the cancellation of three public school heating and ventilating contracts held by Gillis & Geoghegan, the ground for the cancellation being that the firm, through its alleged association in the John T. Hettrick "Code of Practice," was in collusion with other bidders. The three contracts total $333,260.

Will Consider Housing Problems

Most of the sessions of the Chamber of Commerce of the United States at Washington Jan. 27 and 28 will be devoted to housing problems. The three main topics will be: The social and civic effects of housing shortage; effects of building stagnation on business conditions; and the housing of employees by industrial concerns. John Ihlder, formerly field secretary of the National Housing Association, is head of the newly created Civic Development Department of the Chamber of Commerce of the United States, the headquarters of which are at Washington.

New B. & O. Bridge Placed Over Allegheny River

Replacement of the Allegheny River bridge of the Baltimore & Ohio R.R. at 33rd St., Pittsburgh, was successfully completed Dec. 20 with a series of rolling and jacking operations by erecting forces of the American Bridge Co. The new bridge is at a higher level than the old structure built in 1884.

Ohio Highway Commission Asked To Reduce Road Estimates

Governor James M. Cox of Ohio has requested the Ohio Highway Commission to reduce the estimates on all highway construction jobs after Jan. 1 by 20 per cent. He maintains that reduction in costs of labor and materials justify such reductions. Contract bids exceeding the estimates are not accepted, thus estimates are held to be a criterion of the cost of the work.

Dilution of British Building Trades Operatives Blocked

According to recent dispatches from London the British National Federation of Building Trades Operatives has decided not to accept the invitation of the Labor Minister to discuss a scheme for absorbing 50,000 unemployed ex-service men in the building industry. In view of the fact that the building trade is in need of many thousands more workers the government had been negotiating with the unions concerned for the purpose of arranging for the dilution of labor by the introduction of unemployed ex-service men. The government's plan has been readjusted several times to meet the objections raised by the unions and the final proposals were discussed at a recent meeting, ending in the indicated refusal of the building trades workmen to have their personnel diluted.

Senate Reconstruction Committee to Broaden Scope

The senate committee on reconstruction, of which Senator Calder, of New York, is chairman, has been given, through recent Senate action, permission to employ counsel, with the limitation that the salary to be paid shall not exceed $5,000. The action of the committee in broadening its scope and increasing its powers has been the result of recent developments made by the Lockwood joint legislative committee on housing, which is investigating the building situation in New York City. It is the intention of the Senate committee on reconstruction to continue its nation-wide investigation of the housing problem and to include an inquiry of the building trade situation in practically every state in the Union.

It is understood that the Senate committee has the power to grant immunity to witnesses, a power which the Lockwood committee does not directly possess. It is also understood that the Senate committee is considering Samuel Untermyer, counsel for the Lockwood committee, as its counsel.

New York Cut Stone Contractors Plead Guilty and Are Fined

When arraigned before Justice McAvoy, of the criminal branch of the Supreme Court, New York, last week, the thirty-one members of the New York Cut Stone Contractors Association, indicted by the grand jury as a result of evidence produced by the Lockwood joint legislative committee on housing, pleaded guilty to the charge of collusion in bidding and were fined $5,000 each.

California Highway Finance Board Is Organized

Organization of the California highway finance board, which was created by an amendment at the November election, as announced in *Engineering News-Record*, Nov. 11, p. 962, was effected on Dec. 14. Governor W. D. Stephens is chairman; F. W. Richardson, state treasurer, is vice-chairman; and N. D. Darlington, chairman of the state highway commission, is secretary.

To clear up all matters in connection with the sale of the bonds a friendly suit is to be entered at once in the Supreme Court. Meantime the state treasurer is to prepare the bonds so that they may be offered for sale when the decision is rendered.

Pennsylvania Builds 410 Miles of Concrete Roads in 1920

The State Highway Department of Pennsylvania during the 1920 construction season built approximately 410 miles of 18-ft. concrete roadway. In 1919 253 miles were completed. Illinois makes the closest approach to Pennsylvania's record, having put down approximately 339 miles of concrete during the present season.

The maintenance forces of the state highway department during 1920 entirely resurfaced 377 miles of macadam highway and surface treated 1,480 miles of the same type. In all, the maintenance forces maintained 9,503 miles of roadway. Of this mileage 463 miles were in boroughs and an state-aid roads.

Pennsylvania now has under construction approximately 350 miles of concrete roads, the completion of which will be impossible this year because of the lateness of the season. The department plans the awarding of contracts for an additional 350 miles of concrete roadway early in 1921 and hopes to be able to complete not less than 600 miles of durable highways next year.

Water Supply Paper Wins Prize

The prize committee of The Municipal Engineers of the City of New York has awarded the prize for the most meritorious paper read before the society in 1919 to Frank E. Hale, chief chemist Department of Water Supply, Gas and Electricity and director of the Mount Prospect Laboratory, New York City, for his paper on "The Safeguarding of the Water Supply of New York City.

ENGINEERING SOCIETIES

Calendar

Annual Meetings

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City, Jan. 19-20, 1921.

ASSOCIATED GENERAL CONTRACTORS, Washington, D. C.; New Orleans, Jan. 25-27.

ENGINEERING INSTITUTE OF CANADA, Montreal; Toronto, Feb. 1-3.

The Engineers' Society of Milwaukee was addressed Dec. 15 by T. Chalkley Hatton, chief engineer, Milwaukee Sewerage Commission, on "The Progress Made on the Sewage Disposal Plant to Date."

The Minnesota Joint Engineering Board at a meeting Nov. 27 elected the following officers: President, Adolph F. Meyer; vice-president, H. T. Downs; secretary-treasurer, Hans J. Meyer. Six societies have ratified the constitution of the proposed Minnesota Federation of Architectural and Engineering Societies.

The Mohawk Valley Engineers' Club, Utica, N. Y., at its annual meeting elected the following officers: President, Byron E. White; first vice-president, Horace B. Sweet; second vice-president, William B. Foster; third vice-president, Charles T. Myers; secretary, George I. Putnam; treasurer, Clifford Lewis, Jr. The meeting was addressed by O. J. Childs, chief engineer, O. J. Childs Fire Extinguisher Co., who gave facts about fire losses.

The Illinois Section, Am. Soc. C. E. and the **Chicago Engineers' Club** were addressed Dec. 10 by S. T. Henry, vice-president, Allied Machinery Co. of America, on "Opportunities for American Engineers and Contractors in Latin America."

The Engineers' Club of Baltimore is planning to occupy new quarters in the Merchants and Manufacturers' Association Building.

The Florida Engineering Society will hold its annual meeting at Lakeland, Fla., Feb. 7 and 8. Matters of interest to engineers to be brought before the State Legislature will be discussed and action taken.

The Washington Society of Engineers on Dec. 15 elected the following officers: President, R. L. Faris; vice-president, Lieut.-Col. F. W. Albert; secretary, A. C. Oliphant; treasurer, G. P. Springer.

The Engineers' Club of Trenton, N. J., has elected the following officers: President, C. R. Waller; vice-president, H. F. Harris; second vice-president, J. W. Thompson; secretary, J. E. English; treasurer, J. H. Johnson.

The Providence Engineering Society at a meeting Dec. 7 was addressed by Dr. Katherine M. H. Blackford, character analyst, on "Reading Character at Sight."

The Duluth Engineers Club recently received from its committe appointed to examine the proposed Minnesota Registration Act a report endorsing such legislation, but pointing out certain undesirable features of the Joint Engineering Committee's bill, particularly section 2 which would authorize non-registered individuals to conduct professional work The report was signed by D. E. Woodbridge, chairman, T. W. Hugo, Park Fuller, F. H. Fitzgerald and H. J. Underhill.

PERSONAL NOTES

MAURICE A. LYNCH has resigned as acting district engineer, Pennsylvania State Highway Department, with headquarters at Smethport, Pa., and is now with the Kohler Co., Philadelphia, Pa., manufacturer of enameled plumbing ware and power and light installations.

FAY M. RAYMOND, recently with Burns & McDonnell, consulting engineers, Kansas City, Mo., as supervising engineer on the water-works improvement work at Erie, Kan., has accepted a position as supervising engineer in charge of paving work in Neosho County, Kan.

JOHN KLORER, for eight years assistant state engineer, La., has been appointed city engineer, New Orleans, La.

A. M. EVANS has resigned as city engineer of Norwich, N. Y.

CAPT. M. L. WORRELL, who for three years has been serving in the Utilities Section, Construction Division, U. S. Army, has received his discharge from the army and has taken a position with the U. S. Bureau of Public Roads as highway engineer.

O. H. DRAPER has entered the employ of Anniston, Ala., to be associated with Assistant Engineer E. L. Woods on paving work.

DR. CRAIG ARNOLD has been appointed engineer for the State Highway Department of Georgia.

C. P. C. BERESFORD has, after seven years on the West Coast of Africa, resigned his position as general manager of Prestia Co., to take up the post of consulting engineer to the Patino Interests in Bolivia, with head office at Oruro.

F. C. WYSE has resigned as city engineer of Columbia, S. C., to enter the engineering and contracting business.

W. S. TOMLINSON, formerly head of the Tomlinson Engineering Co., has been appointed city engineer of Columbia, S. C.

JOHN K. HARRIS has been appointed borough engineer of Sharon, Pa.

HUNTER A. HAMMILL, formerly an instructor in civil engineering, University of Pennsylvania, is now connected with the engineering department, Bell Telephone Co. as engineering assistant.

DANIEL B. GOODSELL, recently an advisory engineer on roads to the Construction Division, War Department and formerly assistant engineer, Bureau of Highways, Borough of Manhattan, New York, has been appointed field engineer of the Portland Cement Association for the Tidewater District of Virginia with headquarters in Richmond.

HOWARD H. GEORGE, who has been connected with the Public Service Railway Co., Newark, N. J., since 1906, has been appointed engineer maintenance of way. During the World War he commanded Company A, 55th Engineers and served with them in France in charge of building construction of the Chateauroux storage depot project, and on railroad construction at Le Havre.

E. R. DAVIS, formerly assistant city engineer, Newport News, Va., has been promoted to the position of chief engineer.

CHARLES A. POHL, a member of the firm of Bogart & Pohl, consulting engineers, New York, has been appointed chief engineer of the Niagara Gorge Railroad Co.

MAURY NICHOLSON, formerly chief engineer, Chickasaw Utilities Co., Birmingham, Ala., has been appointed highway engineer for Mobile County, Ala.

GEORGE COTTINGHAM, JR., formerly roadmaster, Northern Pacific Ry. at Carrington, N. D., is now engineer maintenance of way, Eastern Division, Chicago Great Western R.R., with headquarters at Chicago.

R. W. WILLIAMS, assistant to the chief engineer, Southern Railway at Washington, D. C., has been appointed engineer maintenance of way and structures of the Southwestern district, with headquarters at Chattanooga, Tenn.

F. H. MOYER, chief engineer, Cambria Steel Co., has resigned to accept a position as works manager, Pittsburgh Crucible Steel Co., Midland, Pa.

ALBERT W. DILLING, acting engineer of bridges, Department of Public Works, Chicago, has been appointed chief engineer of the Sanitary District of Chicago, succeeding E. J. Kelly, who has held the position since George M. Wisner resigned in May. Previous to his present position which he has held since April, Mr. Dilling was engineering assistant to the commissioner of public works for three months, being assigned to look after the city's interests in connection with the Union Station development. Mr. Dilling's first five and one-half years of engineering experience was gained with the Chicago, Milwaukee & St. Paul Ry. Co. Thence he went with the Universal Portland Cement Co. for two and one-half years as assistant engineer, and finally as field engineer in the promotion department. While in railroad service he studied law and has been admitted to the bar. He is a member of the board of directors of the Western Society of Engineers and has been active for a number of years in its affairs.

OBITUARY

JOHN SCOTT, for several years active in Canadian railway enterprises, died Dec. 6 at Winnipeg, Canada. He was a designer and builder of bridges, took part in the Hudson Bay road building and was also connected with provincial drainage operations.

CHARLES J. MCDONOUGH, division engineer, New York State Highway Department, died in Buffalo last week. He was born in Buffalo in 1883 and was graduated from Rensselaer Polytechnic Institute, 1897. From 1898 to 1904 he was with the Bureau of Engineering, Buffalo, on paving work, first as leveler and later as assistant engineer in charge of pavement maintenance. He then entered the service of the state as assistant engineer on barge canal work. In 1907-1909 he acted as first assistant engineer in charge of contract from Tonawanda to Pendleton and then in 1910 was named resident engineer. Important projects which were directly under his supervision were the erection of seven highway bridges across the canal, excavation, culverts, docks, guard-gate and lock walls.

JOSEPH H. CUNNINGHAM, hydraulic and civil engineer, died Dec. 5 at Portland, Ore.. He was born at Danville, Ill., 1863. From 1883 to 1885 he served an apprenticeship under the city engineer and county surveyor of Danville, Ill.; 1886 to 1887, resident engineer, Mobile & Birmingham R.R., Ala., in charge of construction of from 30 to 60 miles; 1888 and 1897 to 1898, asssitant engineer, city engineer's office, Los Angeles, Cal.; 1889 to 1891 in general practice, Portland, Ore.; 1892, assistant engineer, Bear Valley Irrigation Co., Cal., and later with the Washington Water Power Co., Spokane, Wash. During 1894 and 1895 he was assistant U. S. Engineer, Williamette River surveys and improvements; 1896, assistant engineer, city engineer's office, Salt Lake City, Utah, in charge of sewers and steam gagings. Since January, 1899, he had been in general practice as civil and hydraulic engineer in Portland.